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Engineering Company
September 1976

ROCK RIVER

rock island county

Strategic Planning Study
Flood Damage Reduction Plan

Illinois Department of Transportation
Division of Water Resources



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STRATEGIC PLANNING STUDY
FOR
FLOOD DAMAGE REDUCTION
LOWER ROCK RIVER ROCK ISLAND COUNTY

Prepared For
State of Illinois
Department of Transportation
Division of Water Resources

By
Harza Engineering Company

September 1976



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SUMMARY LETTER

September 15, 1976

Division of Water Resources
Department of Transportation
State of Illinois
2300 South Dirksen Parkway
Springfield, Illinois 62764

Attention : Dr. Leo M. Eisel

Subject : Strategic Planning Study For
Flood Damage Reduction Measures,
Lower Rock River, Rock Island County

Gentlemen :

We are pleased to present a plan for alleviating damages from open-water flooding along the Lower Rock River in Illinois. The plan involves construction of levees and flood proofing of structures. It was selected from among five alternative plans for reducing flood damages along the lower 13 miles of the Rock River valley. It is judged to be the most feasible plan, technically and economically, based on our studies of flooding problems and estimates of damage.

The Recommended Plan

The recommended plan, shown on Exhibit 12, involves construction of levees at five locations to protect approximately 1,000 structures against flooding from the 100-year flood. The levees would be constructed outside the floodway. An additional 360 structures, located within the floodway limits, and 20 structures outside the floodway, would be flood proofed to the 100-year flood level. Flood

proofing would consist of elevating structures to a level at which point-of-water entry is one foot above the 100-year flood level. Other flood-proofing measures would include waterproofing basements, installing closure panels over doors and windows and construction of small dikes and levees. Access roads to flood-proofed structures are located in the floodway and would not be improved. A program of raising these roads has been carried out by local townships since the April, 1973 flood. Additional raising would be prohibitive economically and would increase flood stages.

The project benefit-cost ratio is about 1.6. The capital cost for plan implementation is \$2,550,000, which amount includes construction, contingency, engineering and administrative costs. Annual costs for operation and maintenance would be about \$7,100. Equivalent annual costs of plan implementation, including replacement and operation and maintenance, are \$178,300, assuming a discount rate of 6-3/8 percent and a 50-year project life. Average annual benefits from plan implementation, including mitigation of flood damages from open-water and ice-related floods, are \$282,400.

Residual average annual damages in the entire study area, after plan implementation, are estimated to be \$146,400. Some \$90,000 of the estimated residual damages are due to an assumption that levees would be overtopped by any flood exceeding the 100-year event. Overtopping of levees would probably occur less frequently than this because the designs provide two to three feet of freeboard and the potential for sand bagging exists. Therefore, this component of residual damages was conservatively estimated. The remaining \$55,000 of residual damages includes costs for temporary housing, lost wages and economic activity, clean-up, emergency relief for property owners denied access during flooding periods, and damages outside of the levees from floods in excess of the level of protection.

The selected plan provides a high level of performance reliability and we believe it will be acceptable to most property owners in affected areas. No long-term adverse environmental effects have been identified. Some diminishment of aesthetic

values may result from elevating structures in the floodway. However, this measure has been implemented by some 100 owners since the 1973 flood.

Implementation of flood-proofing measures is disruptive but only to those receiving the protection and only for a relatively short period of time. Levee construction has only a minor disruptive effect. Plan implementation may be staged, if necessary, to meet the availability of financing by constructing levees around each of the five damage-prone areas at separate times. Flood proofing may be accomplished on a structure-by-structure basis as funds become available.

The Bi-State Metropolitan Planning Commission has conceptualized a long range program for public acquisition of properties and recreational and open-space development of the Rock River valley corridor. Execution of this conceptualized program would not be precluded by implementation of flood proofing to structures in the floodway as included in the recommended plan. Flood-proofing benefits would be reduced if acquisition of these non-conforming use structures were begun within the assumed 50-year economic life of the recommended plan. However, the recommended plan would remain economically favorable.

Alternative Plans

Alternative plans for alleviating flood damages in the study area were developed in the following sequence:

1. Individual plan elements were identified;
2. Plan elements that did not meet minimum objectives were screened out; and
3. Compatible plan elements were grouped into alternative plans.

Alternative plans meeting the minimum objectives of flood protection are listed in Table A and described below. These

plans include flood-protection measures identified by local interests. Plan-evaluation criteria and an evaluation of the ability of each plan to meet these criteria are shown in Table A.

Measures to protect damage-prone areas which lie in the floodway are limited to non-structural or river-control improvements by virtue of proposed floodway encroachment regulations. Approximately 30 percent of the structures and 50 percent of the potential damages are in the floodway.

Alternative 1 - Flood Proofing

Flood proofing of structures is an economical alternative and would probably have wide acceptance by owners of affected properties. Many structures in the floodway would require raising by as much as six feet. This might diminish the aesthetic value of the area, but it probably would be considered as acceptable by the area residents since a number of owners have already resorted individually to house raising.

Alternative 2 - Levees and Flood Proofing

In the damage-prone areas that lie outside the floodway, both levees and flood proofing of affected structures are economically attractive. Levees are slightly more economical, would permit access during flood periods, and would have a lesser effect on aesthetic values than would flood proofing. For these reasons, levees have been given preference outside the floodway.

Alternative 3 - Levees, Evacuation and Recreational Development

Total evacuation of the flood plain would be uneconomical and would likely be viewed as unacceptable by the affected property owners. However, limited evacuation of the floodway combined with construction of levees and restriction of the floodway and adjacent floodway fringe areas to open space-recreational land uses may be the most desirable long-range solution to current flooding problems in the area.

Alternative 4 - Dredging

Dredging as an alternative would be extremely costly due to the lack of a nearby spoil area. This alternative was rated as having low reliability of performance due to uncertainties about sediment refill rates and the occurrence of rock in the riverbed.

Alternative 5 - I&M Canal and Sears Dam Improvements

The alternative of improving Sears and Steel Dams or the I&M Canal does very little to lower flood stages and consequent damages and it is not economically attractive.

Alternatives to Reduce Ice-Related Flood Damage

There are two causes of flood damages on the Lower Rock River, those caused by ice-jamming and consequent increases in river stages and the so-called open-water floods of spring and summer. In the Ice-Related Flood Report, Rock River Near Moline, Illinois, September, 1975, eight alternatives to reduce ice-related flood damage were identified. It was concluded that ". . . The estimated benefits from alleviating ice-related flooding are not sufficiently large to justify implementation of a large scale structural flood protection plan designed solely to control ice or suppress ice formations on the Lower Rock River." The measures proposed in the recommended plan would eliminate the majority of the ice-related as well as open-water flood damages.

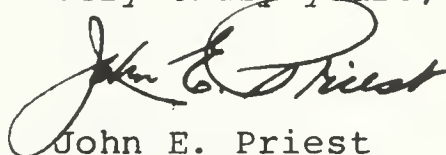
Conclusions

The plan of levees to protect damage-prone areas in the floodway fringe and flood proofing of structures in the floodway, without raising access roads, is the most desirable combination of plan elements, and is justified economically. We recommend that this plan be implemented.

Division of Water Resources
September 15, 1976
Page Six

We appreciate the opportunity to have participated in these interesting studies, and we would be pleased to be of further assistance.

Very truly yours,

A handwritten signature in cursive script, reading "John E. Priest". The signature is written in dark ink and is positioned above the printed name.

John E. Priest
Project Director

ity <u>ance</u>	Public <u>Acceptance</u>	Overall <u>Attractiveness</u>
Le od	Favorable	Very Good
FL	Favorable	Fair
Le		
at	Unfavorable	Fair
Dr	Favorable	Fair
I&		
	Favorable	Poor
—		
<u>1/</u>		
<u>2/</u>		
<u>3/</u>		

Table A

EVALUATION OF ALTERNATIVE PLANS
FOR FLOOD DAMAGE ALLEVIATION
LOWER ROCK RIVER NEAR MOLINE

Plans	Economic Evaluation				Annual Net Benefit \$	Benefit Cost Ratio	Reliability of Performance	Public Acceptance	Overall Attractiveness
	Capital Cost ^{1/} \$	Annual O&M \$	Annual Cost ^{2/} \$	Annual Benefit \$					
<u>Recommended</u>									
Levees and Flood Proofing	2,550,000	7,100	178,300	282,400	104,100	1.6	Very Good	Favorable	Very Good
<u>Alternatives</u>									
Flood Proofing	2,870,000	400	196,100	297,000	100,900	1.5	Good	Favorable	Fair
Levees and Evacua- tion with Recreational Development	20,700,000	209,000	1,240,000	1,041,000 ^{3/}	-199,000	0.8	Excellent	Unfavorable	Fair
Dredging	2,610,000	85,000	259,000	155,200	-103,800	0.6	Fair	Favorable	Fair
I&M Canal and Sears Dam Improvements	1,340,000	63,100	152,800	58,800	-94,000	0.4	Good	Favorable	Poor

^{1/} Includes construction, contingency, engineering and administrative costs.

^{2/} Includes capital, replacement and operation and maintenance costs.

^{3/} Includes recreation benefits of \$762,200 annually.

FOREWORD

FOREWORD

Authorization

The studies described in this report were performed in accordance with the terms of a contract dated 6 October 1975 between Harza Engineering Company (Harza) and the Division of Water Resources (DWR), Illinois Department of Transportation.

Scope of Study

The study area comprises the lower 13 miles of the Rock River and its flood plain from the Green River confluence to its mouth at the Mississippi River. Portions of the Cities of Rock Island and Moline, portions of the Villages of Milan and Coal Valley, and unincorporated communities and farmlands lie within the Rock River flood plain in the study area. The flood plain is used for agricultural, residential, and commercial purposes.

The scope of study includes investigations of open-water flooding and related problems in the area and identification and evaluation of alternative measures for mitigating flood damages.

Prior Studies and Reports

The results of prior investigations concerning flooding in the study area include:

1. House Document No. 173 of the 85th Congress, 1st Session, 1957 indicates that "...flood control improvements along Rock River from mile 4.6 to the mouth of Green River, mile 13, are not economically feasible".
2. The Ice-Related Flood Report, Rock River Near Moline, Illinois September, 1975 prepared by Harza for the DWR concludes that flood damages caused by ice-related floods could be partially mitigated by selective flood proofing and removal of some damage-prone structures. It was recommended that implementation of these measures be delayed until damages from open-water flooding were assessed.

3. Floodplain Information Reports on both the Rock River in Rock Island County and the Mississippi River in Rock Island County in Illinois and Scott and Muscatine Counties in Iowa published in 1969 by the U.S. Army Corps of Engineers define the flood problem.
4. The General Design Memorandum for Flood Protection for Milan Illinois by the U.S. Army Corps of Engineers, Rock Island District, 1974, recommends that levees be built to protect the Village of Milan.

Acknowledgments

The assistance of federal, state, and local agencies in conducting these investigations is greatly appreciated. The U.S. Army Corps of Engineers, Rock Island District, provided hydraulic data, profiles of historic floods, backwater analyses, operating procedures for Mississippi River dams, and valuable insights into the hydraulic performance of the Rock River. The office of the National Oceanographic and Atmospheric Administration, National Weather Service, at Quad Cities Airport, provided stage records of the Rock River at Moline, Illinois. The U.S. Geological Survey discharge records for the Rock River at Joslin, Illinois, and for the Green River at Geneseo, Illinois, for the Mississippi River at Clinton, Iowa and for the Wapsipinicon River at DeWitt, Iowa were used in the hydrologic analyses. The Rock Island County Assessor's Office provided data used to evaluate damages and benefits. The American Red Cross, Civil Defense, and the Bi-State Metropolitan Planning Commission provided information concerning disaster relief and socio-economic characteristics of the area. The Quad Cities Development Group and the Chambers of Commerce of Rock Island and Moline provided information on business and commercial establishments in the flood plain.

Personnel of the DWR provided valuable assistance throughout the course of the studies. In particular, the following persons were especially helpful:

Dr. Leo Eisel	Director
Bruce Barker	Chief, Bureau of Program Development
John Carlisle	Chief, Federal Projects Management
Al Kellerstrass	Project Manager

Their cooperation is gratefully acknowledged.

Principal participants of Harza's staff were:

J. E. Priest	Project Director
E. J. Gemperline	Project Manager
R. E. Aten	Head, Water Resources Division
H. E. Schoeller	Head, Resource Evaluation Department
R. W. Revell	Chief Hydrologist
Dale Book	Civil Engineer
Daryl Price	Civil Engineer
E. Van Nugtren	Graphics Supervisor
E. J. Docekal	Graphics Illustrator

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1	Project Location and Vicinity Map
2	Flood Damage Areas
3	Lower Rock River Discharge-Frequency Relationship
4	Mississippi River Discharge-Frequency Relationship
5	Rock River Flood Profiles (5 sheets)
6	100-Year Flood Inundated Area (13 sheets)
7	Location of Plan Elements
8	Plan Element Evaluation Summary (3 sheets)
9	Evaluation of Alternative Plans for Alleviation of Flood Damage, Lower Rock River Near Moline
10	Layout of Plan Elements (2 sheets)
11	Potential Open-Space Land Use
12	Recommended Plan

REPORT

CHAPTER I

THE RECOMMENDED PLAN

Chapter I

THE RECOMMENDED PLAN

The recommended plan for mitigating flood damages along the Lower Rock River, as shown on Exhibit 12, involves construction of 5 levees and flood proofing of 380 structures located in the Lower Rock River flood plain. The plan was selected from among a number of alternative plans developed by analyzing 32 plan elements, several of which were identified during previous studies and by local interests.

Capital costs (construction, contingency, engineering, and administration) for the levees and flood proofing measures are estimated at \$2,550,000. Annual operation and maintenance expenses would be about \$7,100. Equivalent annual costs^{1/}, including those of amortization, replacement, operation and maintenance, are \$178,300 while annual benefits are \$282,400. The benefit-cost ratio is a favorable 1.58.

Residual average annual damages after plan implementation are estimated to be \$146,400. Of these about \$90,000 are due to the assumption that any flood exceeding the 100-year event would overtop the levees. However, because designs provided for two to three feet of freeboard and because of the potential for sand bagging, levees would probably be overtopped less frequently. Therefore, this estimate of residual damage is conservative. The remaining \$55,000 in residual damages includes costs for temporary housing, lost wages and economic activity, clean-up, emergency relief for property owners denied access during flooding periods, and damages outside of the levees from floods in excess of the level of protection.

Plan Components

Technical Description

The following sections provide technical descriptions of individual components of the recommended plan.

^{1/} Based on a discount rate of 6-3/8 percent and a project life of 50 years.

Levees. Five earthfill levees would be constructed to protect Damage Areas 10, 12, 14 through 18 and 26 through 31. These structures would range in height up to 13 feet and have a mean height of 5.3 feet. As shown on Exhibit 10 (Sheet 1 of 2), the typical levee would have a top width of ten feet for construction and maintenance purposes and two or three feet of freeboard above 100-year flood levels depending on levee height. Side slopes range from 2:1 to 3:1 depending on levee height. Appurtenant facilities include interior drainage works to prevent ponding of storm and seepage water behind the levee and pumping units to dispose of accumulated water.

The five levees would have a combined length of 37,300 feet and would require 167,000 cubic yards of earthwork to construct. About 54 acres of land (50- to 100-foot strips of land along the proposed levee alignments) would have to be purchased for construction and borrow areas. Preliminary analyses of soils along the proposed alignments indicate that soils in the immediate vicinity generally are adequate for use in levee construction. Embankment material for several sections of Levee 2 may have to be hauled from borrow pits near the Quad City Airport.

Levee alignments would be located far enough from the main Rock River channel so that flow velocities would not cause erosion. Embankment protection would be provided by seeding of the levees and adjacent borrow areas. Roads and drives crossed by levees would be built up to the grade of the levees to permit access.

Interior drainage facilities including ponding areas, gravity outlets, gatewells, sluice gates and pumping units would be provided at locations where levee alignments cross present or proposed drainage ditches, or natural streams. In some locations it may be more economical to reroute water from one drainage area to another to prevent duplication of facilities.

Preliminary analyses to determine sizes and locations of drainage facilities included consideration of the entire drainage area tributary to each stream at the levee alignment. Gravity outlets, gatewells, sluice gates and pumping units would be provided at 11 locations in the five levees. Seven of these would be in Levee 2 and one in each of the other levees. Four other gates would be required for existing culverts. These culverts are in road embankments which

would serve as portions of the five levees. Drainage to these culverts would be diverted to a pumping unit during times when the gate is closed.

More detailed analysis may indicate that it is more economical to tie a levee back on either side of a stream rather than provide a drainage facility at that location. This applies more to Levee 2 than the other four levees since Levee 2 would cross several large streams and the other levees would not.

Flood Proofing. Protection of structures located in the floodway would be provided by flood-proofing measures which include elevating structures above 100-year flood levels; waterproofing of basements; installing moveable panels over first-floor doors and windows; and constructing small dikes and floodwalls.

Many residents in the flood plain already have had their homes elevated above certain historic high-water levels. Elevating structures above the 100-year flood level would normally involve raising by use of hydraulic jacks, construction of new concrete block foundations and placement of new footings, and replacement of the structure on the new elevated foundation. About 370 structures not protectable by levees because they are in the floodway would be elevated in this manner.

Approximately 20 structures would be flood proofed by waterproofing of basements in addition to being raised. Typical basement waterproofing measures include: installing footing drains; overcoating outside basement walls with a sealant; installing a wet well and a sump pump, and providing closure panels for basement windows. Approximately ten other structures subject to first-floor flooding would be provided with closure panels for doors and windows or with small dikes and floodwalls to prevent floodwater from entering the structure.

Additional flood-proofing measures such as minor foundation anchoring, overhead sanitary sewers, and sewer check valves also could be implemented if required. Flood-proofing measures would be adapted for each structure and should be determined in more detail prior to actual implementation.

Performance

Plan implementation would eliminate all damages to structures and their contents from floods equivalent to or less than the 100-year flood in those areas protected by levees and flood-proofing measures. Dangers to public health and safety and anxiety and inconvenience caused by flooding would be reduced. Flood-proofing measures have the additional advantage of lessening the severity of damages that would be caused by discharges in excess of the 100-year recurrence interval flood. Because access roads to flood-proofed structures would not be raised, indirect damages such as lost wages, temporary housing costs, and emergency relief service costs would not be reduced in the flood-proofed areas. Such indirect damages would be reduced in areas protected by levees.

Effective performance would require a rigorous program of preventative maintenance for levees, interior drainage facilities, and flood-proofing components. Particular attention should be given to replacement of eroded levee sections and maintenance of grass cover to prevent erosion, thereby minimizing the possibility of levee breaching at weakened sections.

Economic Justification

Each of the elements in the recommended plan were evaluated individually using a discount rate of 6-3/8 percent and a 50-year period of evaluation to determine annual costs and benefits. A summary of this evaluation is presented in Table I-1. A breakdown of construction, replacement, and operation and maintenance costs is included in Chapter V, "Evaluation of Alternative Plans".

Table I-1

EVALUATION OF THE RECOMMENDED PLAN

Plan Element	Capital Cost \$	Annual Cost \$	Number Structures Protected	Average Annual Damages		Average Annual Benefits \$	Annual Net Benefits \$	Benefit Cost Ratio
				Before Implementation	After Implementation			
Levee to Protect Damage Areas 10, 14 - 18	610,000	44,710	451	82,220	37,130	45,090	380	1.01
Levee to Protect Damage Area 28	215,000	15,680	398	98,000	36,220	61,780	46,100	3.94
Levee to Protect Damage Area 12	113,000	8,270	93	22,470	7,490	14,980	6,710	1.81
Levee to Protect Damage Areas 26 & 27	101,000	7,720	33	9,250	2,400	6,850	- 870	0.89
Levee to Protect Damage Areas 29 - 31	97,000	7,250	37	11,190	6,360	4,830	-2,420	0.67
Flood Proofing								
Damage Area 1	512,000	34,580	119	73,590	20,920	52,670	18,090	1.52
Damage Area 2	154,000	10,310	39	24,410	7,920	16,490	6,180	1.60
Damage Area 3	52,000	3,510	13	8,030	1,090	6,940	3,430	1.98
Damage Area 4	80,000	5,320	21	18,000	3,870	14,130	8,810	2.66
Damage Area 5	21,000	1,370	6	5,510	1,100	4,410	3,040	3.22
Damage Area 6	86,000	5,730	23	15,280	2,910	12,370	6,640	2.16
Damage Area 7	187,000	12,540	50	25,560	5,510	20,050	7,510	1.60
Damage Area 8	107,000	7,240	31	17,400	4,450	12,950	5,710	1.79
Damage Area 9	100,000	6,700	35	6,020	3,160	2,860	-3,840	0.43
Damage Area 11	3,000	200	1	320	110	210	10	1.05
Damage Area 13	0	0	0	240	240	0	0	-
Damage Area 19	0	0	0	80	80	0	0	-
Damage Area 20	48,000	3,200	11	6,090	3,300	2,790	-410	0.87
Damage Area 21	14,000	960	3	1,260	470	790	-170	0.82
Damage Area 22	45,000	3,040	12	3,300	1,120	2,180	-860	0.71
Damage Area 23	0	0	0	0	0	0	0	-
Damage Area 24	0	0	0	510	510	0	0	-
Damage Area 25	0	0	0	10	10	0	0	-
Damage Area 32	0	0	0	70	70	0	0	-
Total	2,545,000	178,330	1,376	428,810	146,440	282,370	104,040	1.58

1/ Structures in these areas are not damaged by 100-year flood.

Environmental and Aesthetic Considerations

A detailed evaluation of the environmental effects of implementing the recommended plan was not undertaken. Such an evaluation should be made prior to plan implementation. Levee construction would require clearing, stripping, and excavating in areas with heavy brush and trees thereby reducing the quality of local wildlife habitat. Because of levee maintenance requirements, disrupted lands would not revert back to their former state after construction. The amount of land affected in this manner, however, is small when compared to the total land in the area available for wildlife. Flood proofing of structures by elevating them to levels above the 100-year flood and waterproofing basements is not expected to produce adverse environmental effects. Many flood-plain structures already have been flood proofed in this manner without resulting damage to the environment.

A temporary reduction in the aesthetic value of the area would occur during levee construction. However, because the average levee height is only 5.3 feet and because the area of construction would be reseeded and well maintained, the aesthetic values of areas adjacent to the levees would not be significantly reduced. Flood proofing involves elevating approximately 370 structures, of which 100 would be raised five feet or more. This may have a detrimental effect on the residential aesthetic value of the area.

The proposed levees would divide some fields currently used for agriculture and would reduce ease of access between fields on either side of the levee. However, reductions in crop damages should offset inconvenience caused by loss of direct access.

Implementation Schedule

The recommended plan could be constructed in one year. The actual implementation period would depend on the time required for legal proceedings, securing local cooperation and financing, undertaking detailed engineering designs, purchasing necessary land, bidding, and letting contracts. Plan components are amenable to staged implementation to meet funding availability since levees can be constructed individually at different times and flood proofing can be accomplished on a structure-by-structure basis.

Compatibility With Regional Plan

The Bi-State Metropolitan Planning Commission has identified, conceptually, a long-range program for public acquisition of the floodway and floodway fringe areas for subsequent recreational development of open-space lands. Costs and benefits for implementing such a program were estimated by Harza for a 10-year acquisition period during which complete evacuation of those portions of the 100-year flood plain not protected by levees could be accomplished. These costs are presented for reference only, since a program such as this probably would require a significantly longer period for implementation.

Clearing of the flood plain not protected by levees would involve the purchase of approximately 450 homes, 11 businesses and 2,200 acres of land. Structures would be demolished and lots cleared, and residents would be compensated for their moving expenses. The total cost of flood-plain evacuation would be \$18,500,000. If this plan were implemented uniformly over a period of ten years the discounted total cost would be \$13,300,000 and the equivalent annual cost would be \$892,000.

Floodway evacuation and subsequent restriction to open-space land use is not economically attractive unless the cleared land is put to a beneficial use. Preliminary investigations of the potential use of the floodway and adjacent fringe areas as recreational areas indicates that significant benefits would accrue to this use if appropriate investments were made in recreational facilities. Annual benefits conservatively estimated at \$762,200 would result from an investment of \$1,110,000 initially or \$267,000 as equivalent annual costs with replacement, operation and maintenance, and adjustments for a ten-year implementation period. Recreational opportunities which could be provided in the floodway areas include hiking, bicycling, and horseback riding, picnicking, fishing, camping, boat launching, and nature-study areas. The combined annual benefits of this alternative including recreational use of the floodway and adjacent areas, flood-damage reduction in evacuated areas and flood-damage reduction in the leveed areas, totals \$1,041,000. The estimated annual cost of these measures would be \$1,240,000, yielding a benefit-cost ratio of about 0.8.

The planning commission concept of public acquisition of properties in the floodway would not be precluded by flood proofing. Benefits of flood proofing 380 structures were calculated for a 50-year discount period, and implementation of an acquisition program before the end of that period would somewhat reduce these benefits. However, flood proofing of 380 structures would remain economically feasible if total removal were not accomplished in one to two decades. Benefits for the levee elements of the plan, which will protect nearly 1,000 structures, would be unaffected. Structures could be flood proofed initially and later acquired as they come onto the open market. Recreational development may be staged to coincide with the gradual acquisition of the floodway. As described in Chapter IV, immediate evacuation of the flood plain would cause serious social and political effects particularly the displacement of 1,200 residents. Execution of this plan in the gradual manner described above would eliminate the need for condemnation and greatly reduce social and political obstacles.

CHAPTER II

PROBLEMS AND OPPORTUNITIES

Chapter II

PROBLEMS AND OPPORTUNITIES

Both open-water and ice-related flooding cause hazards to public health and safety, damages to property, and inconvenience to residents along the Lower Rock River. Opportunities exist for alleviating flood damages through implementation of structural and non-structural measures for flood control.

Flood Problems

Causes of Flooding

Open-water floods, caused by discharges which exceed bankfull channel capacity, occur during the spring and summer months. Spring floods result from combined runoff of snowmelt and concurrent moderate to heavy rains in the Rock River Basin. Summer floods occur during periods of widespread, long-duration rainfall. Concurrent high stages on the Mississippi River can increase flood stages on the Rock River thus increasing the extent of flooding.

Ice-related flooding is caused by accumulation of ice on river structures with resultant constrictions to flow and by ice jams that increase river stages above the banks even when discharges are lower than bankfull capacity. The characteristics of ice-related flooding are discussed in Harza's earlier study. 1/

1/ Ice-Related Flood Report, Rock River Near Moline, Illinois Harza Engineering Company, 1976.

Historic Floods

Water-stage observations have been made since 1929 by the National Weather Service (NWS) for the Rock River near the present location of the U.S. Route 150 bridge at river mile 7.3. Discharge records have been kept by the U.S. Geological Survey (USGS) for the Green River at Geneseo since 1936 and for the Rock River at Joslin since 1940. The records of these stations and previously published reports were used to derive flood-frequency relationships and to compile the list of the major open-water floods on the Lower Rock River shown in Table II-1. Specific information concerning the two most severe floods on the Rock River in the study area is provided below.

April 1973 Flooding. The flood of record in the study area occurred during the period April 20 - May 1, 1973 and had an instantaneous peak discharge of 49,700 cfs at the Moline gage.^{1/} The river reached a peak stage of 16.15 feet at the Moline gage^{2/} on April 26. It was followed immediately by the flood of May 1 - June 1, 1973 which reached a peak stage of 14.60 feet on May 5, 1973. From March 8 - March 23, 1973, the Rock River also was out-of-banks and peaked at 13.0 feet on March 11, 1973. These floods were caused by heavy rains falling on saturated soil and aggravated by high base flow in the Rock and Mississippi Rivers.

May 1974 Flood. The second highest flood occurred during the period May 17 through June 5, 1974 and had an instantaneous peak discharge of 46,900 cfs. The peak stage of 15.7 feet at Moline was reached on May 21. This flood was caused by several consecutive days of heavy rainfall over the Rock River basin.

Flood Damages

Information obtained from field reconnaissance; interviews with federal, state, and local agencies, and interested citizens; and reference sources indicates that some residences and establishments in the flood plain suffer open-water flood damage every year. This damage is due to lack of access to homes and businesses, major structural damage, and damage to contents.

-
- 1/ The March, 1948 flood had a greater discharge but only reached a stage of 14.8 feet at the Moline gage.
 - 2/ The datum of the Moline gage is 551.34 ft. msl. (1929 general adjustment).

Table II-1

MAJOR FLOODS OF THE ROCK RIVER AT ITS MOUTH
FOR THE PERIOD 1940-1974

<u>Water Year</u>	<u>Date</u>	<u>Estimated Discharge</u> ^{1/} cfs
1948	3/22	49,900
1973	4/23	49,700
1974	5/20	46,900
1946	1/9	44,000
1971	2/23	42,100
1960	4/3	41,900
1948	2/29	41,800
1974	1/29	39,400
1944	3/18	39,000
1943	3/18	38,400
1973	5/4	38,400
1962	3/22	37,600
1951	7/11	36,100
1974	6/25	35,700
1951	2/28	34,800
1955	10/13	33,000
1952	3/15	32,500
1969	1/25	31,300
1960	1/16	31,200
1960	4/20	30,100
1950	3/8	29,800
1974	6/11	29,800
1973	3/9	28,700
1972	8/27	28,300
1949	3/7	28,200
1949	2/28	28,100
1943	2/26	27,300
1966	2/15	27,300
1959	4/7	26,900
1974	3/7	26,500
1973	1/2	26,400
1952	7/22	26,300
1946	3/18	26,100
1965	4/8	24,400
1973	6/18	23,800

^{1/} Estimated by summing discharges at Geneseo and Joslin and transposing by drainage area ratio.

A methodology for estimating flood damages based on the frequency of the Rock River floods, structure elevations and characteristics and depth-damage curves of the Federal Insurance Administration is described in Chapter V, "Evaluation of Alternative Plans."

Damage-Prone Areas. Exhibit 2 shows the 32 principal residential and commercial flood-damage areas in the study area. They extend on both banks from Hennepin Island at river mile 2.5 to Friendship Farms at the mouth of the Green River. The areas were identified through hydrologic and hydraulic investigations described in Chapter III, and sources cited above.

Floods of the magnitude of the April 1973 event can be expected to occur on average about once in 15 years (15-year recurrence interval). The 1973 flood caused damage to 257 structures in the study area. The 100-year open-water flood would cause direct damage to approximately 1,350 homes and 32 businesses and public buildings. A total of approximately 2,000 homes and 46 businesses are within the limits of the 500-year open-water flood.

Approximately 320 homes and seven businesses located along the banks of the Rock River in damage areas 1-8 also are subject to damage from ice-related floods. The 100-year ice-related flood would affect 102 residences and 3 business establishments and would have a stage about 4 feet lower than the 100-year open-water flood stage at the Moline gage.

Monetary Losses. Total average annual flood damages in the study area are estimated to be \$428,800. Average annual damages in each damage area are listed in Table II-2. Of the total, open-water floods cause estimated damages of \$360,900 to residences, \$41,800 to industrial and commercial establishments, and \$4,600 to public and institutional buildings. These damages include costs of flood fighting and emergency relief services, clean-up, alternative housing and transportation, lost wages, and damages to structures and contents. Average annual flood damages from ice-related floods total \$21,500.

The estimate of damage for the Rock River flood plain was compiled using highly detailed current techniques. Each structure was considered independently. Every parameter which would influence the estimate of damages was carefully obtained. The methodology, described in Chapter 5, "Evalua-

Table II-2

AVERAGE ANNUAL FLOOD DAMAGES BY DAMAGE AREA

<u>Damage Area</u>	<u>Number of Structures Affected^{1/}</u>	<u>Ice-Related Flood Damages</u>	<u>Open-Water Flood Damages</u>
1	119	7,740	65,850
2	39	1,590	22,820
3	13	700	7,330
4	21	3,390	14,610
5	6	1,520	3,990
6	23	3,460	11,820
7	50	2,340	23,220
8	31	800	16,600
9	35		6,020
10	117		20,890
11	1		320
12	93		22,470
13	0		240
14	3		2,120
15	2		230
16	208		32,930
17	82		11,500
18	39		14,550
19	0		80
20	11		6,090
21	3		1,260
22	12		3,300
23	0		0
24	0		510
25	0		10
26	6		1,860
27	27		7,390
28	398		98,000
29	5		3,200
30	12		2,680
31	20		5,310
32	0		70
	<u>1,376</u>	<u>21,540</u>	<u>407,270</u>

^{1/} Number of structures which would be flooded by the 100-year flood.

tion of Alternative Plans", was checked by comparison with an estimate obtained by the U.S. Army Corps of Engineers, Rock Island District of the damage caused by the April, 1973 flood. The Corps surveyed all residents who received flood damage and estimated the total damage in Moline, East Moline and Coal Valley to be \$1,112,000. The estimate obtained for the same areas using Harza's model for the same flood was \$1,176,000. The difference in the two estimates is less than 6% of the actual damage.

Improvement Opportunities

Several improvement measures have been proposed by governmental units and individual property owners in the flood-affected area. Some of these measures already have been implemented while others are being investigated further in these and other studies. Specific descriptions of the latter measures are provided in Chapter IV.

Improvements Completed or Underway

Both structural and non-structural measures for solving flood problems have been implemented or are underway at this time.

Structural Measures. The Division of Water Resources, Illinois Department of Transportation, executed a program of channel improvements in the Lower Rock River during the summer of 1975. These improvements were designed to reduce the potential for ice-jam formations by removal of channel obstructions. The improvements include: a) removal of the rockfill timber crib dam located in the North Channel of the Rock River across from Steel Dam; b) removal of the south abutment of the old U.S. Highway 67 bridge in the South Channel of the Rock River at river mile 3.2 between Hakes Island and the I&M Canal; and c) dredging and clearing under the south end of the Interstate-74 bridge at river mile 7.45.

Non-Structural Measures. Many individual property owners with lots adjacent to the river have raised their homes to elevations exceeding the flood of record or predicted higher flood levels. Many of these same homeowners have raised their lots to meet the grade of access roads which have been raised in several townships.

The City of Moline has an ordinance which prohibits the building of new structures in the flood plain at elevations below 568 feet above mean sea level (ft. msl) approximately the elevation of the flood of record.

The Department of Housing and Urban Development, Federal Insurance Administration currently is conducting Flood Insurance Studies for the Cities of Rock Island and Moline, the Villages of Coal Valley and Milan, and unincorporated Rock Island County. The objective of these studies is to convert the communities and the County from the emergency program to the regular flood insurance program.

Improvements Desired by Local Residents

Several flood-protection and flood-related improvements were identified during discussions with residents of flood-affected areas. Flood-protection improvements mentioned included modifications to Sears and Steel Dam and the I&M Canal, channel modification by dredging, and improvement of access to areas subject to flooding. These potential improvements are described in detail in Chapter IV.

CHAPTER III

HYDROLOGIC AND HYDRAULIC STUDIES

Chapter III

HYDROLOGIC AND HYDRAULIC STUDIES

The hydrologic and hydraulic analyses described in this chapter were performed to determine the extent and frequency of flooding in the study area. These analyses included development of discharge-frequency relationships based on available records of stage and discharge and operating data for Locks and Dams on the Mississippi River. Backwater studies were undertaken to determine water-surface profiles for floods of selected frequencies. The extent of flooding in the study area for the 100-year event was determined from the 100-year flood profile and available topographic mapping.

Hydrologic Studies

Open-water flooding on the Lower Rock River is caused by discharges exceeding bankfull channel capacity coupled with backwater effects from the Mississippi River. Hydrologic analyses were made to determine discharge-frequency relationships for the Rock and Mississippi Rivers and to determine the likelihood of coincident flood peaks.

Basic Data

Discharge and stage records were obtained from the following gages for use in the hydrologic analyses:

Table III-1

DISCHARGE AND STAGE GAGES
ROCK AND MISSISSIPPI RIVERS

<u>Gage Location</u>	<u>Type of Data</u>	<u>Drainage Area</u> sq.mi.	<u>Period of Record</u>	<u>Source</u>
Rock River at Moline	Stage	10,821	1929-present	NWS
Rock River at Joslin	Discharge	9,551	1939-present	USGS
Green River at Geneseo	Discharge	1,003	1936-present	USGS
Mississippi River at Clinton	Discharge	85,600	1873-present	USGS
Wapsipinicon River at DeWitt	Discharge	2,330	1934-present	USGS

Discharge-Frequency Relationships

Discharge-frequency relationships were developed for the Rock River at Moline and the Mississippi River at the mouth of the Rock River. These relationships were used in determining water-surface profiles for floods of selected frequencies in the study reach. Analytical procedures are fully documented in Planning Memorandum No. 1 prepared by Harza and submitted to the Division of Water Resources in April 1976.

The discharge-frequency relationship for the Rock River at Moline is based on records for gages on the Rock River at Joslin and Moline and on the Green River at Geneseo. The discharge of the Rock River at Moline was estimated by summing discharges at Geneseo and Joslin and transposing the values using the square root of the ratio of the drainage

areas. The thirty-five annual peak flows at Moline determined in this manner for the period of record 1940-1974 were analyzed for frequency of occurrence using the Log Pearson Type III method. The resulting discharge-frequency relationship was not significantly different from a relationship prepared by the U.S. Army Corps of Engineers (Rock Island District) based on discharge of the Rock River at Joslin.^{1/} Because the Corps' discharge-frequency relationship (Table III-2 and Exhibit 3) currently is in use in the study area, it was selected for use in this study.

Table III-2

DISCHARGE-FREQUENCY RELATIONSHIP
ROCK RIVER AT MOLINE

<u>Return Period Year</u>	<u>Frequency</u>	<u>Partial Series Discharge^{2/} (cfs)</u>	<u>Annual Series Discharge (cfs)</u>
500	.002	108,000	108,000
200	.005	89,000	89,000
100	.01	76,000	76,000
50	.02	65,000	65,000
25	.04	55,000	55,000
10	.10	43,000	43,000
5	.20	35,200	34,300
2	.50	25,900	22,800
1.25	.80	18,700	14,000

The discharge-frequency relationship for the Mississippi River at the Rock River confluence was developed based on the discharge-frequency relationship for the Mississippi River at Clinton, Iowa, developed by the Corps of Engineers, and adjusted by multiplying discharges by the square root of the ratio of the drainage areas. This relationship is summarized in Table III-3 and shown on Exhibit 4.

^{1/} Milan, Illinois, General Design Memorandum, U.S. Army Corps of Engineers, Rock Island District, November, 1974.

^{2/} Estimated from the annual series using factors proposed by W. B. Langbein.

Table III-3

DISCHARGE-FREQUENCY RELATIONSHIP
MISSISSIPPI RIVER AT THE ROCK RIVER CONFLUENCE

<u>Return Period Years</u>	<u>Frequency</u>	<u>Discharge cfs</u>
500	.002	465,000
200	.005	385,000
100	.01	347,000
50	.02	309,000
25	.04	275,000
10	.10	227,000
5	.20	190,000
2	.50	136,000
1.25	.80	97,000

Coincidence of Flooding

Flood stages in the study reach are partly dependent upon Mississippi River stages at the Rock River confluence. The interrelationship of flooding on the two rivers was analyzed to establish the most probable Mississippi River discharges at the time of flooding on the Rock River and the most likely Rock River discharges at the time of flooding on the Mississippi River. The results of these investigations are presented in Planning Memorandum No. 2 submitted by Harza to the Division of Water Resources in April 1976.

Rock River peak discharges usually occur during the spring snowmelt. Flooding also may result from heavy rainfalls during summer or fall. Mississippi River floods occur in late spring or early summer as a result of the accumulation of snowmelt from the upper part of the watershed. Lesser peaks occur as the result of localized snowmelt and heavy rainfall. Analysis of spring floods on the Rock River and coincident discharges on the Mississippi River demonstrate that Rock River flood peaks normally coincide with stage rises on the Mississippi River. The stage rises on the Mississippi usually result from warming effects in the local region of the Rock River which also cause the Rock River to peak. Subsequent Mississippi River peaks exceed

this rise as warming extends northward affecting a larger portion of the total watershed. Analysis of flooding on the Rock River caused by heavy rainfalls indicates that summer peaks on the Rock River normally coincide with minor peaks on the Mississippi River which result from the same storms. Table III-4 lists the highest Rock River floods during the period 1940-1974, together with coincident Mississippi River discharges for the same date.

A least-squares regression analysis of flood flows of the Rock River and coincident discharges of the Mississippi River (Table III-4) gives the following relationship:

$$Y_1 = 1.77 X_1 + 29,800 \text{ (Equation 1)}$$

Where:

X_1 = flood discharge of the Rock River at its mouth in cfs,

Y_1 = coincident discharge of the Mississippi River at the confluence with the Rock River in cfs.

Hydrographic analysis of spring floods on the Mississippi River and coincident Rock River discharges indicates that peak discharges on the Mississippi River normally occur two to four weeks after the Rock River peaks. Table III-5 lists the 35 annual peak floods of the Mississippi River and the coincident Rock River discharges for the period 1940-1974.

A least squares regression analysis of flood flows of the Mississippi River and coincident Rock River discharges (Table III-5) gives the following result:

$$Y_2 = 0.0225 X_2 + 9000 \text{ (Equation 2)}$$

Where:

X_2 = flood discharge of the Mississippi River in cfs;

Y_2 = coincident discharge of the Rock River in the study reach in cfs.

Table III-4

THIRTY-FIVE HIGHEST FLOODS ON THE ROCK RIVER AND COINCIDENT
MISSISSIPPI RIVER DISCHARGES FOR THE PERIOD 1940-1974

Water Year	Date	Estimated Discharge in cfs	
		Rock River at Confluence ^{1/}	Mississippi River at Confluence ^{2/}
1948	3/22	49,900	104,900
1973	4/23	49,700	176,200
1974	5/20	46,900	104,300
1946	1/9	44,000	97,880
1971	2/23	42,100	85,200
1960	4/3	41,900	142,300
1948	2/29	41,800	82,400
1974	1/29	39,400	49,300
1944	3/18	39,000	65,890
1943	3/18	38,400	81,480
1973	5/4	38,400	130,750
1962	3/22	37,600	78,700
1951	7/11	36,100	150,750
1974	6/25	35,700	160,750
1951	2/28	34,800	79,250
1955	10/13	33,000	52,550
1952	3/15	32,500	65,050
1969	1/25	31,300	50,800
1960	1/16	31,200	57,200
1960	4/20	30,100	107,800
1950	3/8	29,800	93,550
1974	6/11	29,800	100,480
1973	3/9	28,700	76,900
1972	8/27	28,300	77,980
1949	3/7	28,200	72,840
1949	2/28	28,100	39,800
1943	2/26	27,300	43,550
1966	2/15	27,300	91,900
1959	4/7	26,900	105,300
1974	3/7	26,500	73,700
1973	1/2	26,400	77,700
1952	7/22	26,300	65,880
1946	3/18	26,100	106,420
1965	4/8	24,400	100,800
1973	6/18	23,800	96,500

^{1/} Estimated by summing discharges at Geneseo and Joslin and multiplying by 1.01.

^{2/} Estimated by summing discharges at Clinton and DeWitt.

Table III-5

THIRTY-FIVE ANNUAL FLOODS OF THE MISSISSIPPI RIVER
AND COINCIDENT ROCK RIVER DISCHARGES
FOR THE PERIOD 1940-1974

Water Year	Date	Estimated Discharge in cfs			Coincident Discharge as Percent of Peak Discharge
		Mississippi River at Confluence ^{1/}	Rock River at Confluence ^{2/}	Rock River Peak During Event ^{2/}	
1965	4/28	309,600	13,800	24,400	57
1969	4/25	235,780	11,100	15,700	71
1952	4/27	227,600	13,600	21,300	64
1951	4/26	225,070	12,000	18,300	66
1973	3/25	213,450	19,400	26,500	73
1967	4/14	202,400	8,700	17,800	49
1944	6/28	188,700	11,400	13,100	87
1954	5/14	177,450	4,700	16,300	29
1942	6/13	174,800	9,900	11,200	88
1971	4/23	169,790	9,900	17,500	57
1945	3/31	169,020	6,900	7,400	93
1974	6/24	166,450	36,900	36,900	100
1943	6/30	159,840	5,300	11,500	46
1972	5/2	157,280	11,400	22,100	52
1960	5/18	155,600	21,800	23,200	94
1961	4/2	151,000	14,900	16,400	91
1946	3/28	148,540	18,800	26,100	72
1966	4/1	146,710	11,000	12,800	86
1962	4/21	141,500	15,400	37,600	41
1968	7/7	133,630	8,900	10,800	82
1947	6/15	132,540	11,100	16,100	69
1941	4/25	131,460	9,400	22,100	43
1950	5/22	131,130	5,100	23,900	21
1956	4/20	127,600	4,400	10,200	43
1948	3/20	124,800	34,900	49,900	70
1959	4/3	122,600	24,100	28,100	86
1953	4/5	106,300	9,800	14,400	68
1957	7/14	103,460	4,400	4,400	100
1955	4/25	101,240	16,300	16,300	100
1970	6/8	95,620	16,000	21,900	73
1963	4/2	93,750	9,400	14,100	67
1949	4/7	88,540	9,200	12,200	75
1964	5/20	85,050	5,200	7,000	74
1940	6/19	74,329	1,900	5,200	37
1958	4/15	65,420	5,600	6,400	88

^{1/} Estimated by summing flows at Clinton and at DeWitt.

^{2/} Estimated by summing flows at Joslin and Geneseo and multiplying by 1.01.

Hydraulic Studies

Hydraulic studies involved using results of the hydrologic analyses to determine water-surface profiles on the Rock River for discharges associated with the 1.25-, 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence interval events. Profile determinations were made using the Corps of Engineers HEC-2 step backwater computer program. Preliminary limits of the 100-year floodway also were determined by computer analysis. Hydraulic studies are documented in Planning Memorandum No. 3 submitted by Harza to the Division of Water Resources in July 1976.

Basic Data

Channel cross-sections from soundings made by DWR in May 1968, were provided by the Corps of Engineers for 25 locations along the 13-mile Lower Rock River study reach. Overbank conditions at cross-section locations were obtained from orthophoto maps (1"=400 feet with 2-foot contour intervals) provided by the Division of Water Resources. Supplemental overbank information was obtained from survey data obtained by the Corps in May 1968. As-built drawings of the five bridges and two dams in the study reach were obtained from several sources. Channel and overbank roughness coefficients (Manning's n-values) were selected from field reconnaissance and modified during calibration of the backwater model.

Calibration Procedures

The backwater model was calibrated by comparing computed water-surface elevations to observed high-water marks for the April 1959, April 1973, and May 1974 floods. The latter two floods overtopped the river banks, and the flood of 1959 remained within the channel. High-water marks were provided by the Corps of Engineers. Channel and overbank roughness values were modified to obtain a good match between computed elevations and historic high-water marks. Small differences between computed and recorded elevations were permitted to avoid unreasonable variations in roughness coefficients. Discharges and starting conditions for the historic floods were obtained from available data sources.

Starting Conditions

The Rock River enters the Mississippi River 3.8 miles downstream from Lock and Dam No. 15 and 21.9 miles upstream

from Lock and Dam No. 16 on the Mississippi River. A tailwater rating curve for Lock and Dam No. 15 was obtained from operating diagrams for the Lock and Dam. It is based on both Mississippi River and Rock River discharges. Operating diagrams for Lock and Dam No. 16 provide a headwater rating curve for this structure, based on Mississippi River discharges which are approximately the sum of Rock River discharges and Mississippi River discharges upstream from Lock and Dam No. 15. Straight-line interpolation between the tailwater rating at Lock and Dam No. 15 and the headwater rating of Lock and Dam No. 16 provided the rating curve for the Mississippi River at the mouth of the Rock River. This rating was used to determine the starting condition for each backwater computer run.

Flood Profiles

Water-surface profiles on the Rock River were computed for the 1.25-, 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year floods on both the Rock and Mississippi Rivers using the regression equations of coincident flooding and previously noted discharge-frequency relationships for the Rock River at Moline and the Mississippi River at the mouth of the Rock River.

For the condition of high Rock River flood discharges, the coincident Mississippi River discharges were determined using Equation 1. The water levels obtained for the coincident Mississippi River discharges were used as the starting water-surface elevations for backwater computations. Rock River water-surface profiles were then determined using these water levels and the Rock River discharges.

For the condition of high Mississippi River flood discharges, the coincident Rock River discharges were determined using Equation 2. Backwater computations were then made using the coincident Rock River discharges and the starting water-surface elevations obtained for the Mississippi River flood discharges.

Flood profiles which are the envelope of profiles computed for the two conditions were then drawn for each flood frequency. High Mississippi River floods cause high water levels on the Rock River in the reach from the confluence with the Mississippi River upstream to Sears and Steel Dams at Vandruff Island. High Rock River floods cause high water levels upstream of the dams. The water-surface profiles are shown on Exhibit 5.

Floodway

Floodway limits for the 100-year flood were determined using the equal conveyance option of the HEC-2 program. Equal conveyance assumes similar encroachment onto the flood plain for both the right and left overbanks. Stage rises above the 100-year flood profile were limited to 0.1 feet throughout the study reach.

Inundation Maps

Flood-inundation maps were prepared using available orthophoto base maps and computed flood profiles. These maps were used to estimate flood damages, to locate alignments for levees, and to determine levee heights and flood-proofing requirements.

CHAPTER IV

FORMULATION OF ALTERNATIVE PLANS

Chapter IV

FORMULATION OF ALTERNATIVE PLANS

A full range of concepts for reducing flood damages in the Lower Rock River area were considered. They include: channel improvements; levees; flood proofing; flood plain evacuation; modification of existing dams and water-control structures; and diversions. Specific plan elements for mitigating flood damages at different locations were identified, screened, and evaluated on common bases of engineering practicability, cost effectiveness, and environmental, aesthetic, and social implications. Compatible plan elements, which would protect one or more damage-prone areas, were combined to form alternative plans to alleviate flooding problems and reduce damages in the study area.

Plan Elements

A total of 32 individual plan elements were considered. They are variations of seven main flood-protection measures or the same measure applied at different locations. They include eight different types of gates or diversions at Sears and Steel Dams and the I&M Canal, levees at 12 different locations, flood proofing of two different areas, raising access roads, two evacuation plans, dredging to two different depths at three different locations, and a plan for recreational use in evacuated areas. The plan elements are described below and summarized on Exhibit 8.

Modifications to Sears and Steel Dams and I&M Canal

Vandruff Island is located between river mile 2.7 and river mile 4.7 and bisects the Rock River into the North Channel and South Channel.

Sears Dam, at river mile 2.97, is located near the downstream end of Vandruff Island in the North Channel. The dam is a concrete gravity overflow structure 16 feet high and 460 feet long, with a crest at elevation 557.84 ft. msl.

Steel Dam is a concrete-faced, rock-fill, overflow structure located at the upstream end of Vandruff Island across the head of the South Channel. It is 6 feet high and 765 feet long and its crest is at elevation 558.34 ft. msl.

A portion of the I&M Canal is located adjacent to the Rock River between Steel Dam and the Mississippi River. The I&M Canal was constructed by the Corps of Engineers between 1882 and 1918. The westerly reaches of it were utilized for navigation until about 1951. Three locks in the Canal (Nos. 30, 31, and 32) have since been plugged with concrete or earth.

Eight plan elements, described below, were considered for lowering the Rock River pool by modification of either the Sears Dam or the Steel Dam or making improvements to the I&M Canal.

Sears Dam. Three plan elements involve modifications to Sears Dam. A gated spillway crest could be constructed in the North Channel downstream from the U.S. Highway 67 bridge to regulate water-surface elevations. The spillway also would provide low-level outlet capacity in the North Channel. This facility would be located downstream from the bridge to avoid adverse effects of discharging toward the bridge piers. The spillway would have two radial gates. Sensing devices would be provided at the gates, and remote controls for gate operation would be considered.

A gated spillway also could be constructed upstream of the highway bridge where it would not be necessary to remove any of the abandoned powerhouse structure. However, it would be necessary to construct a non-overflow section between the new spillway and the existing dam.

The third plan element involves replacement of Sears Dam for its entire length with a 13-foot high Bascule gate. A typical Bascule gate is shown on Exhibit 10 (sheet 1 of 2). The Bascule gate would basically consist of a long leaf-type structure hinged along its bottom edge to the foundation of the dam. An oil pressure cylinder would provide the necessary force to open or close the gate. In the open position, the gate would lie flat on the bottom of the channel and provide an unobstructed passage for flood-water. The gate operation could be automatically controlled by a float-actuated sensing device or operated at an on-site control station.

Steel Dam. Three plan elements consist of modifications to Steel Dam. Two plan elements consist of 3-foot and 6-foot Bascule gates for the full 765-foot length of the dam. A portion of Steel Dam would have to be removed to

permit installation of the gates. The gates would be automatically operated steel leaves that hinge upward from the upstream face of their foundation. Gates would be raised in summer to maintain a recreation pool and lowered during floods to decrease river stages upstream. In winter the gates would be lowered to reduce the quantities of ice that develop and to allow an unobstructed passage of ice. The gates also could be operated to break up ice and facilitate passage of ice during thawing periods.

Hinged flashboards 3-feet high also were considered for the entire length of Steel Dam. A typical hinged flashboard is shown on Exhibit 10 (sheet 1 of 2). The hinged flashboards would be raised during the summer to maintain a recreation pool and lowered during floods to lower river stages upstream. In winter the gates would be lowered to allow an unobstructed passage of ice.

I&M Canal. Two plan elements involving improvements to portions of the I&M Canal were considered. The major plan components are shown on Exhibit 10 (sheet 2 of 2). Two tainter gate bays and remnants of Lock 30 are located at the left abutment of Steel Dam at river mile 4.8. A 200-foot section of the forebay channel upstream of the lock is jammed with logs and debris. Two of the bays have been closed by earth fill, and the gates have been removed. The other bay contains an old, manually operated, tainter gate. The lock has been plugged with earth.

Possible improvements to the I&M Canal would include: removal of debris and earth from the lock area; installation of three new tainter gates to be housed between existing abutments; and provision of a diversion structure and open channel about 200 feet downstream from Steel Dam to divert water from the Canal back to the Rock River. Floodwater would pass under the gates into the Canal, thus providing additional flow area and reducing the stage above Steel Dam.

An alternative plan of improvement involves the passage of floodwater through the Canal and diversion back into the Rock River at the Mill Creek junction. This would involve an additional 0.7 miles of channel dredging and removal of fill near Mill Creek.

Levees and Floodwalls

Levees in combination with floodwalls could be constructed at 12 locations in the damage-prone areas. Two to

three feet of freeboard, depending on levee height, was allowed to protect against wave run up. Levees would have a top width of 10 feet and side slopes ranging from 1:3 to 1:2 depending on levee height. Investigations of soils in the immediate vicinity of the levee alignments indicate that it is suitable for embankment material with one exception. Embankment material for sections of Levee 2 may have to be obtained from borrow areas near the Quad Cities Airport.

Gravity outlets, temporary pumps, gatewells, and sluice gates would be provided to prevent ponding of water inside the leveed areas during storms and during periods of high stage of the Rock River. A typical levee cross section and appurtenant drainage facility are shown on Exhibit 10 (sheet 1 of 2).

Non-Structural Measures

Three non-structural measures were considered: raising access roads; flood proofing of individual structures; and flood-plain evacuation.

Raising Access Roads. Many of the access roads to homes located adjacent to the Rock River are lower than the land on which the homes are constructed. Even minor floods which do not damage the homes may prevent residents from traveling to and from their homes by road. One proposed plan element is to raise the access roads to an elevation approximately equal to the 100-year open-water flood elevation plus one foot of freeboard. Drainage culverts would be provided to ensure that the raised access roads would not act as levees and trap water or constrain overbank flow. Raised access roads would reduce such damages as loss of income, temporary alternative housing costs, and damage to automobiles. South Shore Drive would be raised an additional four to seven feet for its entire length. North Shore Drive would be elevated four to seven feet. Access roads in Damage Areas 4, 5, 6, 7, 8, 11, 12, 15, 16, 17, 18, 20, 21, 22 and 27 would also be raised from two to nine feet. In all, about 13.5 miles of road would be raised from two to nine feet.

Flood Proofing. Flood-proofing measures include raising structures in the flood plain so that their first floor elevations are above the 100-year flood level. Some structures could be waterproofed by installing moveable panels over doors and windows, sealing basements, or by constructing small levees or floodwalls.

Two flood-proofing plans were considered: flood proofing all of the structures in the 100-year flood plain; and alternatively flood proofing all of the structures in the 100-year flood plain except those protected by levees.

Flood-Plain Evacuation. Removal of structures located in flood-prone areas would eliminate their potential for damage entirely. Two evacuation plans were considered: evacuation of all structures in the floodway; and evacuation of all structures in the floodway and floodway fringe except those protected by levees. Highest priority efforts would be devoted to removal of structures in the floodway. Preliminary floodway encroachment studies indicate that there are approximately 350 houses and 13 commercial establishments within the floodway. Complete evacuation of the 100-year flood plain except those protected by levees would require removal of an additional 100 residences. Purchase of the properties would be required, and occupants would be relocated and resettled.

Recreational Use of Evacuated Lands. Land which has been purchased and cleared could be used for recreational or other compatible open-space uses. Development of purchased lands with recreational facilities such as hiking trails, camp grounds, bicycle trails, fishing, boating, nature study, and equestrian trails would provide significant benefits.

Dredging

Dredging of the Rock River in the study area was considered. Many local residents have expressed their belief that dredging the Rock River channel would aid in alleviation of flood damages. Initially, dredging would improve channel conveyance capacity and reduce flood elevations. Dredging would be required on a continuing basis thereafter to maintain channel capacity.

Dredging was considered for three reaches of the Rock River: the North Channel near Vandruff Island; from Sears and Steel Dams to Heritage Additions (damage area 10); and from Sears and Steel Dams to the mouth of the Green River. Two depths of dredging were considered for each reach; one and one-half feet and three-feet on an average below the present channel bottom for a width of approximately 600 feet.

Evaluation of Plan Elements

A screening process involving preliminary technical and cost evaluations was used to select those elements considered to be sufficiently attractive for further consideration as components of specific alternative plans. Twenty-three plan elements or variations of plan elements were eliminated from consideration because of poor performance characteristics and their relatively high costs compared to other plan elements providing similar levels of protection.

Modifications to Sears and Steel Dams

Removal of both Sears and Steel Dams and replacement with 13-foot and 6-foot Bascule gates respectively would lower the water-surface profile of the Rock River immediately upstream from Vandruff Island by approximately 1.7 feet for the 5-year flood and 0.7 feet for the 100-year flood. Smaller stage reductions would result further upstream in damage-prone areas. At the I-74 bridge the stage reduction would be 0.7 feet for the 5-year flood and 0.2 feet for the 100-year flood. The reduction in average annual damages accompanying this stage reduction would be approximately \$55,000, an amount significantly lower than the equivalent annual cost of replacing both dams with Bascule gates (\$645,000).

Removal of the top three feet of Steel Dam and replacement with a Bascule gate or hinged flashboards would result in damage reductions of less than \$55,000. Average annual costs of these modifications would be \$177,000 and \$95,400 respectively. These modifications cannot be justified economically and they were eliminated from further consideration.

Gated spillways at Sears Dam and Powerhouse located either upstream or downstream of U.S. 67, would have similar performance characteristics. The upstream spillway is more costly and was therefore eliminated from further consideration.

Modifications to I&M Canal

Renovation of the I&M Canal and Lock 30 with provision for diversion of flow back into the Rock River just downstream of Steel Dam would result in a greater upstream flood stage reduction than if flow were to be diverted back into the Rock River at Mill Creek. Since the added cost of

renovating the canal to Mill Creek would not result in a greater reduction in flood stages, this plan element was eliminated.

Levees and Floodwalls

Levee-floodwall combinations 6 through 12 were eliminated from further consideration because they would encroach upon the required floodway. Levees 1 through 5, to protect damage areas 10, 12, 14 - 18, and 26-31, are viable plan elements and they were considered further for inclusion in alternative plans.

Dredging

Dredging only the North Channel of the Rock River from Sears Dam upstream to the eastern end of Vandruff Island would have approximately the same effect on water surface profiles as construction of a new spillway at Sears Dam and Powerhouse. Initial dredging to either a one and one-half-foot depth or a three-foot depth would require removal of approximately 200,000 or 550,000 cubic yards, respectively, and an annual channel-maintenance expense. This would be more costly than a gated spillway in Sears Dam and Powerhouse. Dredging of the North Channel, therefore, was eliminated from further consideration.

The cost of dredging the Rock River from Sears and Steel Dams to the Green River would be approximately twice the cost of dredging to Heritage Additions. The incremental benefit of dredging from Heritage Additions to the Green River would be less than five percent of the total benefit of dredging the entire reach. The benefits would not justify the added cost of dredging upstream from Heritage Additions and this was not considered further.

Computer backwater analysis indicates that the stage lowering effects in the reach from Sears and Steel Dams to Heritage Addition would be significant throughout the study reach for dredging either one and one-half or three feet. Dredging approximately one and one-half feet off the channel bottom would result in lowering the 5-year flood by approximately 1.3 feet and the 100-year flood by 0.4 feet throughout the study reach. Dredging three feet would result in lowering the 5-year flood by approximately 1.8 feet and the 100-year flood by 1.4 feet. The cost of dredging to a three-foot depth would be approximately double the cost of

dredging one and one-half feet and would increase benefits by 45 percent. The added cost of dredging to a depth of three feet would not be justified by the additional benefits. Therefore, this alternative was eliminated from further consideration.

Dredging from Sears and Steel Dams to Heritage Additions for a depth of one and one-half feet below the present channel bottom is a viable plan element and was considered for inclusion in alternative plans.

Non-Structural Measures

Raising access roads to structures located adjacent to the Rock River, including North Shore and South Shore Drives would constitute an encroachment on the floodway. The cost of raising access roads would be much higher than the benefits which would be obtained. This plan element was not considered further.

The non-structural measures of flood proofing individual structures to the level of the 100-year flood, flood-plain evacuation, and recreational or open-space use of evacuated land are viable plan elements and were considered for inclusion in alternative plans.

Alternative Plan Formulations

Functional and compatible plan elements were formed into five alternative plans. The basis for formulation was significant reduction of flood damages in the study area.

Alternative 1

Alternative 1 consists of flood proofing every structure which would be damaged by the 100-year flood. Approximately 1,200 structures would be elevated two to seven feet providing first-floor elevations one foot above the 100-year flood elevation. In addition, 140 basements would be waterproofed, 13 commercial structures would be flood proofed by installation of moveable panels over doors and windows, and nine individual floodwalls would be built in locations outside of the floodway.

Alternative 2

Alternative 2 includes construction of Levees 1 through

5 to protect 1,000 structures outside of the floodway, individual flood proofing of approximately 360 structures in the floodway and 20 structures located outside the floodway and not protected by the levees. Much land behind the levees presently is undeveloped because of the flood hazard; it would also be protected. This alternative would eliminate all damages from the 100-year flood, however, access to the flood-proofed structures would not be possible during major floods. Approximately 370 of the 380 homes flood proofed would be elevated two to seven feet, 20 basements would be waterproofed, and ten structures would be protected with moveable panels over windows and doors or small dikes and floodwalls.

Alternative 3

Alternative 3 involves construction of Levees 1 through 5 and purchase and evacuation of all land in the floodplain outside of the levees with reuse of evacuated lands for recreational purposes. Approximately 450 residences, 11 businesses and 2,200 acres of land would be purchased. About 70 of these homes would not receive direct damage but would be without access during the 100-year flood. This alternative would eliminate all flood damage from the 100-year flood in the Rock River flood plain and would have additional benefits from the use of recreational facilities.

Alternative 4

Alternative 4 involves dredging approximately one and one-half feet off the Rock River channel bottom from Sears and Steel Dams to Heritage Additions. This would improve the conveyance capacity of the river and would reduce flood stages for the more frequent floods. Dredging would have to be repeated annually to maintain constant channel capacity.

Alternative 5

Alternative 5 includes renovation of the tainter gates and removal of fill in Lock 30 of the I&M Canal, construction of a diversion structure from the I&M Canal to the Rock River downstream of Steel Dam, and construction of a gated spillway at Sears Dam and Powerhouse downstream of U.S. 67. The gated lock would act as a side channel spillway and some Rock River flow would be diverted around Steel Dam through the I&M Canal, thereby lowering flood stages upstream of Steel Dam. The gated spillway on Sears Dam would further lower upstream water stages.

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CHAPTER V

EVALUATION OF ALTERNATIVE PLANS

Chapter V

EVALUATION OF ALTERNATIVE PLANS

The five alternative plans, described in Chapter IV, were evaluated by comparing their economic aspects, performance characteristics, effects of implementation, and potential for public acceptance, against a common set of evaluation criteria.

Evaluation Criteria

Criteria for evaluation of alternative plans were determined from standards and procedures set forth in flood-control legislation, policies, and regulations of the State of Illinois.

Economic Criteria

The following principles were applied in evaluation of alternative plans:

1. Tangible benefits should exceed project economic costs;
2. Each separable unit of improvement should provide benefits at least equal to its cost;
3. The scope of the development should be such as to provide the maximum net benefits; and
4. There should be no more economical means, evaluated on a comparable basis, of accomplishing the same purpose or purposes that would be precluded from development if the plan were undertaken.

Procedures used to determine the costs and benefits associated with implementation of each alternative plan are the following:

Costs. Cost estimates were prepared for each alternative plan based on engineering layouts of individual plan elements, approximate construction quantities, and unit-cost

data obtained from published sources and discussions with contractors and manufacturers. Construction costs were converted to capital costs by adding 36 percent of the construction cost to account for contingencies, engineering design and surveillance, and administrative services.

The present worth of capital costs was determined by using a discount rate of 6-3/8 percent over the construction period if the period would exceed one year. The present worth costs of replacement facilities were determined by discounting their cost at 6-3/8 percent from the time when replacements would be required. A 50-year project life was assumed for economic evaluation procedures. Amortized costs were determined by calculating the uniform annual costs, over 50 years at 6-3/8 percent that would be equivalent to the total present worth of capital plus replacement costs.

Annual operation and maintenance costs were estimated by determining the specific labor, electric power, equipment and materials requirements for each plan element. Total annual costs are the sum of amortized capital plus replacement costs and operation and maintenance costs. The costs of each alternative plan are presented and described in subsequent sections of this chapter.

Benefits. Annual monetary benefits attributable to each alternative plan are the differences between estimated average annual damages before and after implementation. For this study, benefits were determined based only on current development in flood-affected areas.

Average annual damages were estimated by constructing a damage-frequency curve for each damage-prone structure in the study area. The damage-frequency relationship for each residential structure was established using the discharge-frequency curve for the Rock River at Moline, computed water-surface profiles at the approximate location of the structure, appropriate depth-damage curves developed by the Federal Insurance Administration, and characteristics of the structures including market value and elevation of the lowest point of water entry. The damage-frequency relationship for each commercial or public structure in the study area was established using the characteristics of the structure, including type of construction, value of contents, type of interior walls and flooring, and vulnerability to flood damage.

The entire procedure used to define the damage-frequency curve and to approximate average annual damages was programmed for computation by computer. These analyses are documented in detail in "Detailed Estimation of Ice-Related Flood Damages, Rock River Near Moline, Illinois, July 1975," prepared by Harza Engineering Company.

Three types of flood damage were estimated: structural damage, damage to contents, and indirect damages. Indirect damages, which include lost wages, safeguarding of health and life, and alleviating hardships, were estimated at 15 percent of the total of structural and contents damage for residences. Indirect damages for commercial structures include lost wages and lost business.

Elevations of the lowest point of water entry to residential structures were determined by leveling from USGS and I&M Canal benchmarks. Approximate market values were determined using the assessed values of structures and lots which were obtained from the Rock Island County Supervisor of Tax Assessors. Content values of residences were estimated to be 25 percent of the market value of the structure plus \$1,000.

Elevations of the lowest point of water entry to commercial and public buildings were determined by leveling from USGS and I&M Canal benchmarks. Each commercial and public building in the study area was surveyed to collect data necessary to estimate flood damages. Damages caused by loss of access to the building, including lost business and lost wages, were estimated based on information supplied by the business owner, elevation of access roads, and the annual duration of flooding of access roads and the building.

The benefits associated with each alternative are described in subsequent sections of this chapter.

Performance Characteristics

Performance characteristics considered in evaluation of alternative plans include: reliability; maintenance requirements; ability to provide flood protection for future developments; and the effects of flooding which exceeds the level of protection provided. They are described in following sections of this chapter.

Effects of Implementation

In addition to economic and performance characteristics,

other aspects that were considered in evaluating alternative plans include the effects of implementation on the quality of life, public health and safety, aesthetic values, and the environment. Disruptions and inconveniences caused during construction also were considered. Detailed surveys and analyses of these aspects were not performed during this planning phase. Preliminary judgements were made, however, based on known standards and requirements, available data and information, and opinions and impressions obtained during reconnaissance of the study area.

Public Acceptance

The potential for public acceptance of a particular plan is an important evaluation consideration. The acceptability of each alternative plan was determined on a preliminary basis using previous reports and studies and insights gained from local residents and governmental units during the conduct of the investigations.

Alternative Plan Evaluations

Each of the five alternative plans was compared to the evaluation criteria described above. Results of these comparisons of all alternatives are provided in Tables V-1 and V-3. Average annual damages before and after implementation of each alternative are summarized in Table V-2. The evaluations of alternative plans are summarized in tabular form on Exhibit 9.

Alternative 1 - Flood Proofing

This alternative provides for flood proofing of all damage-prone structures in the study area.

Economic Aspects. The capital cost of implementing this alternative would be \$2,870,000 and the annual cost would be \$196,100. Average annual benefits would be approximately \$297,000 providing a benefit-cost ratio of 1.51. Average annual residual damages would be approximately \$131,800.

Annual costs include initial construction, replacement of sump pumps (\$200 each) every 5 years, reapplication of

basement wall sealants (\$400 per application) every 25 years, and operating costs for pumps at \$0.03 per kilowatt-hour. Annual benefits consist of estimated reductions in annual damages.

Performance Characteristics. Flood proofing measures are reliable means for eliminating damages from floods with stages up to the design level. Flood proofing would provide the additional beneficial effect of reducing damages from floods with stages in excess of the design levels. Sealing of existing basements may not be completely effective in some instances. Maintenance requirements would be minimal and maintenance could be effectively accomplished in most instances by home owners themselves.

Effects of Implementation. Flood proofing of structures would reduce dangers to life, public health, and safety in addition to alleviating anxiety caused by flooding. Since access roads would not be raised, emergency vehicles other than amphibious vehicles or boats could not enter flooded areas. Temporary loss of access during flood periods would continue to cause inconvenience to property owners. Construction would cause temporary disruption and would inconvenience residents for a short time. Residential aesthetic values in the affected area would be diminished by the elevating of structures, many as high as six feet. Flood proofing of structures probably would not cause any adverse effects on the local environment.

Public Acceptance. Because many local residents already have implemented some flood proofing measures a fairly high degree of acceptance can be expected, particularly if funding assistance is provided. Those residents living in the floodway fringe probably would show less enthusiasm for flood proofing than those residing in the floodway.

Alternative 2 - Levees and Flood Proofing

This alternative involves construction of five levees to protect most structures in the floodway fringe and implementation of flood proofing measures to protect all damage-prone structures not protected by levees.

Economic Aspects. The capital cost for implementation of this alternative would be \$2,550,000 and the annual cost would be \$178,300. Average annual benefits which would be associated with Alternative 2 were estimated to be \$282,400.

The benefit-cost ratio is 1.58 and average annual residual damages would be \$146,400.

Annual costs would include the previously noted unit replacement and operating costs for flood proofing, replacement of temporary interior drainage pumps (\$5,000 per unit) every 25 years and annual levee maintenance costs of \$7,050 for minor repairs, inspection, and equipment. Benefits are equivalent to reductions in average annual damages.

Performance Characteristics. The performance characteristics of flood proofing measures are described under Alternative 1. Levees would provide reliable protection for floods up to the design level but could increase flood severity if higher levels cause overtopping or breaching. An effective surveillance and preventative maintenance program would be required to insure proper performance. Levees also would provide protection for areas that could be developed in the future.

Effects of Implementation. As with Alternative 1, implementation of this alternative would reduce dangers to life, public health, and public safety and relieve anxiety caused by flooding. Temporary adverse environmental effects may occur during construction of levees because of the need for large-scale earthmoving and land clearing. Long-term effects on the local environment would probably be minimal. Levee construction would necessitate the clearing of 54 acres of land, much of which currently is used for agriculture. The uncropped land to be cleared is only a small percentage of the total uncropped land in the immediate area.

Public Acceptance. Preliminary indications are that local residents would not be greatly opposed to construction of levees particularly if they are seeded and well-maintained. Significant opposition to flood proofing measures is not anticipated.

Alternative 3 - Levees and Floodway Evacuation

This alternative involves construction of the five levees of Alternative 2 in combination with a program for evacuating residences and commercial establishments from the floodway and those floodway fringe areas not protected by levees. Evacuated lands would be developed for open-space recreational use.

Economic Aspects. The capital cost of implementing this alternative would be \$20,700,000 and the annual cost would be \$1,240,000. Average annual benefits which would accrue would be \$1,041,000 of which \$278,800 would result from reductions in annual flood damages and \$762,200 would result from the recreation concept. The benefit-cost ratio for this alternative would be 0.84, and the equivalent annual residual damages would be \$150,000.

Annual costs would include the cost for recreational development and maintenance and the levee maintenance costs given in Alternative 2. Annual costs for recreation include annual maintenance as well as those which would be required for clean-up and minor repairs to recreation equipment caused by flooding.

Performance Characteristics. The performance characteristics for levees are described under Alternative 2. Evacuation and removal of structures is the most reliable method of eliminating flood damages. Subsequent zoning of the floodway for recreation or other flood-compatible uses would eliminate the possibility of future developments that could be subject to flood damages.

Effects of Implementation. Constructing levees and evacuating homes and businesses from floodway areas would eliminate dangers to life, public health, and public safety for all floods. Implementation also would eliminate anxiety caused by flooding, but the unsettling effect of relocation on many families might offset this beneficial effect. The riverine corridor open spaces resulting from floodway evacuation would be aesthetically pleasing, provide space for recreation, and also improve wildlife habitats. The beneficial environmental effects of this alternative would be considerable. During the period of site and structure removal there would be a short-term decrease in aesthetic values. Of major concern are the potentially adverse sociological effects of relocation.

Public Acceptance. Evacuation of floodway lands would be unacceptable to most persons who would have to relocate. Recreational development of evacuated lands probably would have wide acceptance for those residents in the area not affected by relocation.

Alternative 4 - Dredging

Alternative 4 involves dredging the Lower Rock River

from Steel and Sears Dams upstream to Heritage Addition (damage area 10) to increase channel conveyance capacity and lower flood stages in the study reach.

Economic Aspects. The capital cost of implementing this plan would be \$2,610,000 and the annual cost would be \$259,000. Average annual benefits for dredging due to reduced flood damages would be \$155,200. Average annual residual damages would be \$273,600 and the benefit cost ratio for this alternative would be 0.60. Dredging would also improve opportunities for boating and water skiing resulting in additional recreational benefits. High annual costs result from the need to provide some dredging every year to maintain necessary conveyance capacity.

Performance Characteristics. This alternative would have limited reliability because of the uncertainties concerning the presence of rock near the channel bottom and the rate at which the channel may refill. The total effectiveness of the plan may be limited even with periodic maintenance because of sporadic heavy accumulations of sediment during high flow periods, upstream effects that may temporarily increase sediment transport rates, and increased sediment trap efficiencies in the newly dredged channel. While dredging would significantly reduce river stages for lower frequency floods, the stage-lowering effects would be much less pronounced for less frequent events.

Current federal regulations require that the environmental impacts of dredging on the aquatic ecosystem and the effects of the dredged material on the proposed spoil area be examined before issuance of a permit to dredge. The amount of dredging which would be required initially and on an annual basis thereafter to reduce flood damages in the study reach is so large that adverse environmental effects would probably be significant. Additionally this amount of material could not be disposed of along the immediate riverbanks because of environmental objections but would have to be hauled a considerable distance to acceptable spoil areas. Several borrow areas, no longer used, near the Rock River would be logical choices for fill from dredged material. The possible adverse environmental aspects of this alternative plan cast doubt on whether dredging of the Lower Rock River would be permitted.

Effects of Implementation . Dredging the Rock River one and one-half feet would have a beneficial impact on the

quality of life by reducing flood stages and damages. Implementation of this alternative, however, might create a false sense of security among flood plain residents and reduce the effectiveness of emergency relief programs during floods of high magnitude.

Implementation of this alternative probably would result in significant adverse effects on aesthetic values and the local environment. Aesthetic values would be permanently lowered in locations adjacent to spoil disposal areas. Water-related recreational opportunities would be adversely affected during initial dredging and annual maintenance activities, however, an improved channel would provide better conditions for water skiing and boating. The adverse effects on the aquatic ecosystem of annually disturbing bottom sediments were not examined but it is believed they would be considerable.

Public Acceptance. Dredging probably would be acceptable to most residents in the area since disruptions to normal activities would be minimal.

Alternative 5 - I&M Canal and Sears Dams Improvements

This alternative includes renovation of the I&M Canal to provide discharge downstream from Steel Dam and construction of a spillway at Sears Dam and Powerhouse to provide discharge downstream from U.S. Highway 67.

Economic Aspects. The capital cost of implementing this alternative would be \$1,340,000 and the annual cost would be \$152,800. Average annual benefits which would be associated with Alternative 5 were estimated to be \$58,800 providing a low benefit-cost ratio of 0.39. Average annual residual damages would be approximately \$370,000.

Annual costs which would include painting, care of hydraulic machinery, and inspection were estimated at four percent of the capital costs for the I&M Canal improvements and five percent of the capital costs for improvements of Sears Dam and Powerhouse. Average annual benefits are estimated as reductions in annual flood damages.

Performance Characteristics. Diversion of some Rock River flow upstream from Steel Dam through new tainter gates at Lock 30 on the I&M Canal and back to the Rock River below Steel Dam would be a reliable method for lowering flood

stages upstream of Steel Dam during open-water floods. The tainter gates at Lock 30 would perform with reasonable certainty to allow passage of flow during floods and could be kept closed during non-flood periods to create a recreation pool. Provision of tainter gates would not effectively prevent ice-related floods because of the possibility of ice jamming in restricted forebays. Diversion of water through a new gated spillway in Sears Dam also would be a reliable method of lowering flood stages upstream from Sears Dam during open-water floods. This spillway also could be operated to create a recreation pool during non-flood periods. Improvements would not prevent ice-related floods because of the possibility of ice jams forming in the forebay and restricting flow capacity.

Neither of these measures would significantly lower river stages during infrequent flood events.

Effects of Implementation. Implementation of this alternative would have fewer beneficial effects than other plans since smaller reductions in open-water flood stages would result. The plan would not significantly reduce anxiety or inconvenience because of small stage-lowering effects and inability to control ice-related flooding. Possible short-term adverse environmental effects could occur during construction.

Implementation of this alternative would not affect existing recreation potentials because the tainter gates would be operated to maintain a pool behind Sears and Steel Dams during the recreation season. The overall adverse environmental effects of implementation of this plan would be minor and temporary.

Public Acceptance. These improvement measures would be acceptable to local residents because they would cause only minimal disruptions to normal activities.

Conclusions

The two alternatives: flood proofing, and levees combined with flood proofing; would be cost effective, provide high degrees of protection, be reliable in terms of performance, and would be acceptable to flood plain residents. Flood proofing might be objectionable to the community outside of the flood plain but to a lesser degree when

combined with levees because of the fewer structures involved. Levees would be more cost effective than flood proofing in the areas for which they were considered and would provide protection to access as well as to structures and contents. Alternative 2, levees to protect areas in the floodway fringe and flood proofing of structures in the floodway, therefore, is the most attractive plan. Ultimately, it may be the desire of decision makers to preserve the floodway for flood-compatible land uses. Alternative 3, levees and evacuation of floodway structures with recreational use of evacuated areas would fulfill that objective. This plan also calls for allocation of some currently undeveloped floodway fringe areas for recreational use thereby eliminating the potential for future damages in those areas as well. Initial public reaction to implementation of Alternative 3 likely would be unfavorable. Although the computed benefit-cost ratio is less than one (0.84), recreational benefits were conservatively estimated and secondary benefits such as environmental and aesthetic enhancement, protection of currently undeveloped lands, and resultant improvements to economic base conditions have not been included in computed benefits.

Recommendations

Levees around damage areas 10, 12, 14 - 18, and 26 - 31, and flood proofing of the remaining flood-prone structures in the study area is recommended for mitigating flood damages. This plan meets the immediate and long-term needs of the area residents.

NS

<u>Amortized Capital Plus Replacement Cost</u>	<u>Annual O&M Cost</u>	<u>Total Annual Cost</u>
\$	\$	\$
195,700	400	196,100
171,200	7,100	178,300
1,031,000	209,000	1,240,000
174,000	85,000	259,000
89,700	63,100	152,800

administrative costs.

ect life.

Table V-1

COST EVALUATION OF ALTERNATIVE PLANS

<u>Alternative</u>	<u>Capital Cost^{1/}</u>	<u>Present Worth Values^{2/}</u>		<u>Amortized Capital Plus Replacement Cost</u>	<u>Annual O&M Cost</u>	<u>Total Annual Cost</u>
		<u>Capital Cost</u>	<u>Replacement Cost</u>			
	\$	\$	\$	\$	\$	\$
1 - Flood proofing	2,870,000	2,870,000	56,000	195,700	400	196,100
2 - Levees and Flood proofing	2,550,000	2,550,000	18,000	171,200	7,100	178,300
3 - Levees, Evacuation and Recreation	20,700,000	15,300,000	179,000	1,031,000	209,000	1,240,000
4 - Dredging	2,610,000	2,610,000	0	174,000	85,000	259,000
5 - I&M Canal, Sears Dam Improvements	1,340,000	1,340,000	0	89,700	63,100	152,800

1/ Includes construction cost, contingency, engineering and administrative costs.

2/ Assuming a discount rate of 6-3/8 percent and 50-year project life.

A	Alternative 4		Alternative 5	
	Dredging		I&M Canal, Sears Dam Improvements	
	Residual	Annual	Residual	Annual
	Damages	Benefits	Damages	Benefits
	\$	\$	\$	\$
	51,440	22,150	61,260	12,330
	4,620	9,790	21,250	3,160
	4,690	3,340	6,930	1,100
	0,780	7,220	15,910	2,090
	5,510	0	5,050	460
	5,280	0	13,790	1,490
	7,430	8,130	21,230	4,330
	9,860	7,540	15,100	2,300
	5,100	920	4,530	1,490
1	1,400	9,490	18,090	2,800
1	260	60	250	70
1	5,810	6,660	18,520	3,950
1	170	70	220	20
1	1,190	930	1,870	250
1	80	150	200	30
1	0,410	12,520	28,670	4,260
1	6,680	4,820	10,010	1,490
1	6,490	8,060	12,570	1,980
1	80	0	70	10
2	6,090	0	6,090	0
2	1,260	0	1,260	0
2	3,300	0	3,300	0
2	0	0	0	0
2	330	180	430	80
2	10	0	10	0
2	1,030	830	1,600	260
2	4,160	3,230	6,350	1,040
2	3,920	44,080	85,570	12,430
2	1,800	1,400	2,810	390
3	1,520	1,160	2,370	310
3	2,920	2,390	4,640	670
3	30	40	70	0
T	73,650	155,160	370,020	58,790
E		155,160		58,790

1

2

Table V-2

AVERAGE ANNUAL DAMAGES AND BENEFITS
WITH AND WITHOUT PLAN IMPLEMENTATION

Annual Flood Damages Before Plan Implementation			Alternative 1 Flood Proofing		Alternative 2 Levees and Flood Proofing		Alternative 3 Levees, Evacuation and Recreation		Alternative 4 Dredging		Alternative 5 I&M Canal, Sears Dam Improvements	
Damage Area	Ice Related	Open- Water	Residual Damages	Annual Benefits	Residual Damages	Annual Benefits	Residual Damages	Annual Benefits	Residual Damages	Annual Benefits	Residual Damages	Annual Benefits
	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
1	7,740	65,850	20,920	52,670	20,920	52,670	0	73,590	51,440	22,150	61,260	12,330
2	1,590	22,820	7,920	16,490	7,920	16,490	0	24,410	14,620	9,790	21,250	3,160
3	700	7,330	1,090	6,940	1,090	6,940	0	8,030	4,690	3,340	6,930	1,100
4	3,390	14,610	3,870	14,130	3,870	14,130	0	18,000	10,780	7,220	15,910	2,090
5	1,520	3,390	1,100	4,410	1,100	4,410	0	5,510	5,510	0	5,050	460
6	3,460	11,820	2,910	12,370	2,910	12,370	0	15,280	15,280	0	13,790	1,490
7	2,340	23,220	5,510	20,050	5,510	20,050	0	25,560	17,430	8,130	21,230	4,330
8	800	16,600	4,450	12,950	4,450	12,950	0	17,400	9,860	7,540	15,100	2,300
9		6,020	3,160	2,860	3,160	2,860	0	6,020	5,100	920	4,530	1,490
10		20,890	8,510	12,380	9,280	11,610	9,280	11,610	11,400	9,490	18,090	2,800
11		320	110	210	110	210	0	320	260	60	250	70
12		22,470	7,210	15,260	7,490	14,980	7,490	14,980	15,810	6,660	18,520	3,950
13		240	240	0	240	0	240	0	170	70	220	20
14		2,120	2,120	0	1,690	430	1,690	430	1,190	930	1,870	250
15		230	230	0	210	20	210	20	80	150	200	30
16		32,930	11,470	21,460	17,620	15,310	17,620	15,310	20,410	12,520	28,670	4,260
17		11,500	3,980	7,520	4,970	6,530	4,970	6,530	6,680	4,820	10,010	1,490
18		14,550	3,750	10,800	3,370	11,180	3,370	11,180	6,490	8,060	12,570	1,980
19		80	80	0	80	0	80	0	80	0	70	10
20		6,090	3,300	2,790	3,300	2,790	0	6,090	6,090	0	6,090	0
21		1,260	470	790	470	790	0	1,260	1,260	0	1,260	0
22		3,300	1,120	2,180	1,120	2,180	0	3,300	3,300	0	3,300	0
23		0	0	0	0	0	0	0	0	0	0	0
24		510	510	0	510	0	510	0	330	180	430	80
25		10	10	0	10	0	10	0	10	0	10	0
26		1,860	520	1,340	510	1,350	510	1,350	1,030	830	1,600	260
27		7,390	2,040	5,350	1,880	5,510	1,880	5,510	4,160	3,230	6,350	1,040
28		98,000	29,770	68,230	36,230	61,780	36,220	61,780	53,920	44,080	85,570	12,430
29		3,200	1,380	1,820	1,370	1,830	1,370	1,830	1,800	1,400	2,810	390
30		2,680	1,780	900	2,140	540	2,140	540	1,520	1,160	2,370	310
31		5,310	2,220	3,090	2,850	2,460	2,850	2,460	2,920	2,390	4,640	670
32		70	70	0	70	0	70	0	30	40	70	0
Total	21,540	407,270	131,820	296,990	146,440	282,370	90,510	338,300 ^{1/}	273,650	155,160	370,020	58,790
Equivalent Average Annual Benefits				296,990		282,370		278,800 ^{1/2/}		155,160		58,790

^{1/} Not including \$762,200 in equivalent annual benefits for recreation usage.

^{2/} Assuming implementation uniformly over a ten-year period.

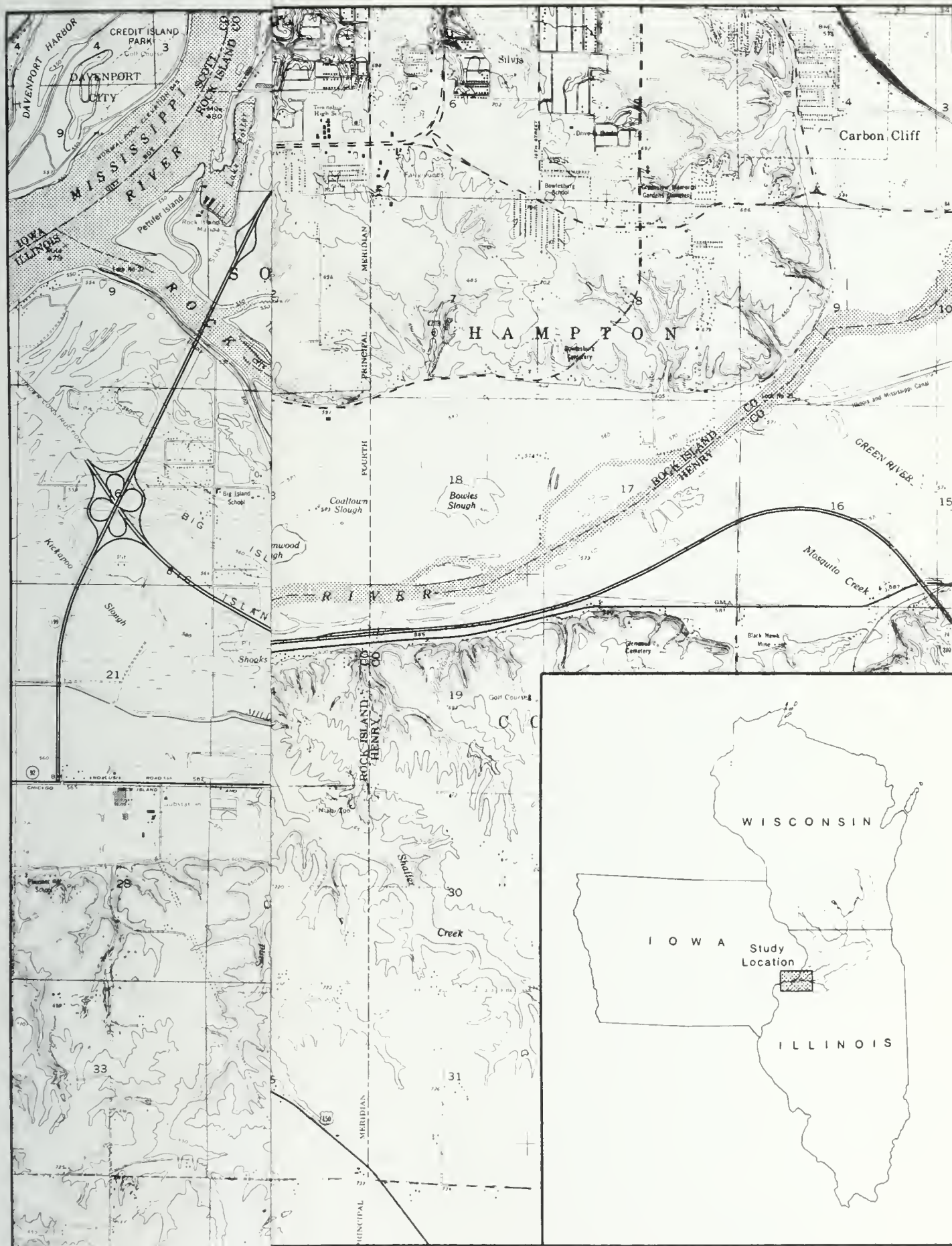


EXHIBIT 1

PROJECT LOCATION

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY

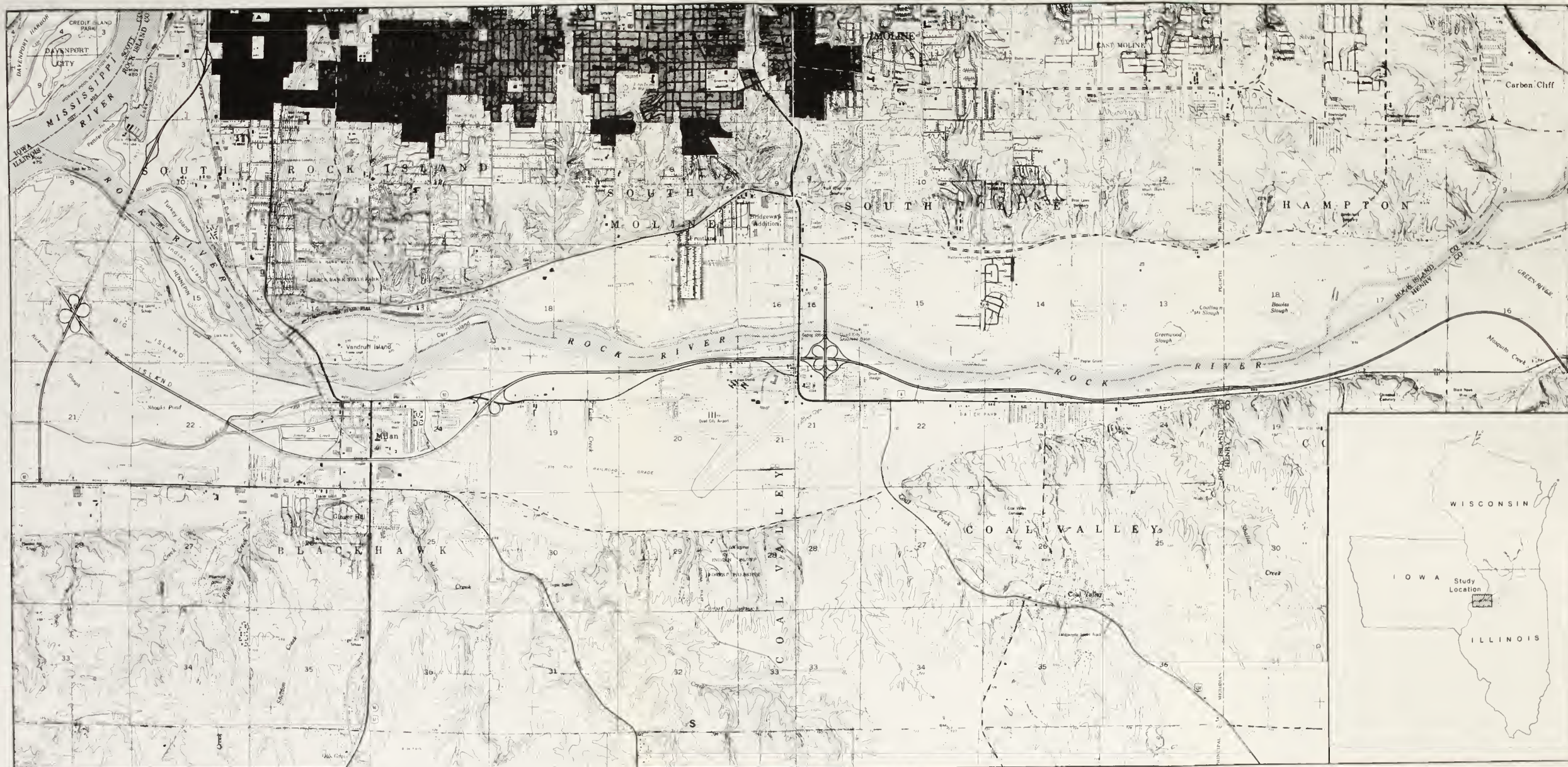


EXHIBIT 1

PROJECT LOCATION

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY

Table V-3

BENEFIT-COST EVALUATION OF ALTERNATIVE PLANS

<u>Alternative</u>	<u>Annual Cost</u> \$	<u>Average Annual Benefit</u> \$	<u>Annual Net Benefit</u> \$	<u>Benefit- Cost Ratio</u>
Flood Proofing	196,100	297,000	100,900	1.51
Levees and Flood Proofing	178,300	282,400	104,100	1.58
Levees, Evacuation and Recreation	1,240,000	1,041,000	-199,000	0.84
Dredging	259,000	155,200	-103,800	0.60
I&M Canal and Sears Dam Improvements	152,800	58,800	-94,000	0.38

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GLOSSARY

GLOSSARY OF TERMS

Consistent terms have been used throughout this report. Definitions of the most frequently used terms are provided as follows:

Average Annual Damages. An estimate of the most probable amount of money needed annually to replace or rehabilitate property that has been or would be subject to damage.

Damage-Frequency Curve. Plot of the amount of damage to a structure (or group of structures) versus the frequency with which that damage occurs. The area between the damage-frequency curve and the damage and frequency axes is defined as the average annual damage. A damage-frequency curve for a structure (or group of structures) can be compiled by knowing: (a) the stage-frequency curve at the structure location; (b) the characteristics of the structure; and (c) the depth-damage curves for the structure.

Depth-Damage Curves. Relationships between depth of water above a given datum in a structure and damage to that structure. Depth of water is normally expressed as feet above first floor or feet above the lowest point of water entry. Damage is expressed as a percent of the market value of the structure and as a percent of contents value in the structure. Depth-damage curves have been compiled for virtually all types of structures. The U.S. Army Corps of Engineers, Soil Conservation Service, and the Federal Insurance Administration all have published depth-damage curves. Relationships published by the Federal Insurance Administration were used in this study.

Discharge-Frequency Curve. Plot of flows versus the frequency that the flow is equalled or exceeded. A discharge-frequency curve is developed by performing a statistical analysis on streamflow records. The Log Pearson Type III method was used in this study and the resulting discharge-frequency curves for the Rock and Mississippi Rivers are shown in Tables III-2 and III-3 and on Exhibits 3 and 4. The discharge-frequency curve is used to derive a stage-frequency curve through backwater analysis for the given discharges.

Flood. Any water stage or flow which is high relative to a given base. For this study a flood on the Lower Rock

River was assumed to occur when the gage height at Moline exceeds 10 feet.

Flood Plain. The relatively flat area or low lands adjoining the channel of a river, stream, or watercourse which has been or may be inundated by floodwater.

Flood Probability. The probability that a flood of given magnitude or greater will occur in any one year. It is the inverse of the flood recurrence interval.

Flood Profile. A graph showing the relationship of water surface elevation to location, generally drawn to show water surface elevation for the crest of a specific flood. The graph also may be prepared for conditions at a given time or stage.

Flood Recurrence Interval. The number of years during which a flood of given magnitude or greater would be expected to occur once. That is, an "N-year flood" is that flood which will, over a long period of time, be equalled or exceeded on the average, once every N years; however, it may occur in any year. N is the recurrence interval.

Floodway. The limit of encroachment on a 100-year flood plain which will not cause an increase in flood heights or velocities.

Floodway Fringe. The area inundated by the 100-year flood between the floodway boundary and the 100-year flood boundary.

Ice-Related Flood. A flood caused or affected by an ice obstruction to flow. Ice jams may increase the water stage of open-water floods or may cause floods during periods when discharges are not high enough to cause open-water floods.

Left Bank. The left side of the river bank when facing downstream.

Obstruction. A physical feature in the river channel which favors the formation of jams, either ice or debris, and restricts the passage of ice flows. Such features are sand bars, islands, dams and bridge piers.

Open-Water Flood. A flood caused by discharges exceeding bankfull capacity during which no temporary obstruction to flow such as log jams or ice jams occur.

Right Bank. The right side of the river bank when facing downstream.

Stage. The elevation of the water surface relative to a specified datum.

Stage-Frequency Relationship. A plot of several river stages versus the frequency with which the stages are equalled or exceeded.

100-Year Open-Water Flood Plain. That area within the inundation lines of the open-water flood with an estimated return period of 100 years.

EXHIBITS

PROJECT LOCATION AND VICINITY MAP

FLOOD DAMAGE AREAS

LOWER ROCK RIVER DISCHARGE-FREQUENCY RELATIONSHIP

MISSISSIPPI RIVER DISCHARGE -FREQUENCY RELATIONSHIP

ROCK RIVER FLOOD PROFILES

100-YEAR FLOOD INUNDATED AREA

LOCATION OF PLAN ELEMENTS

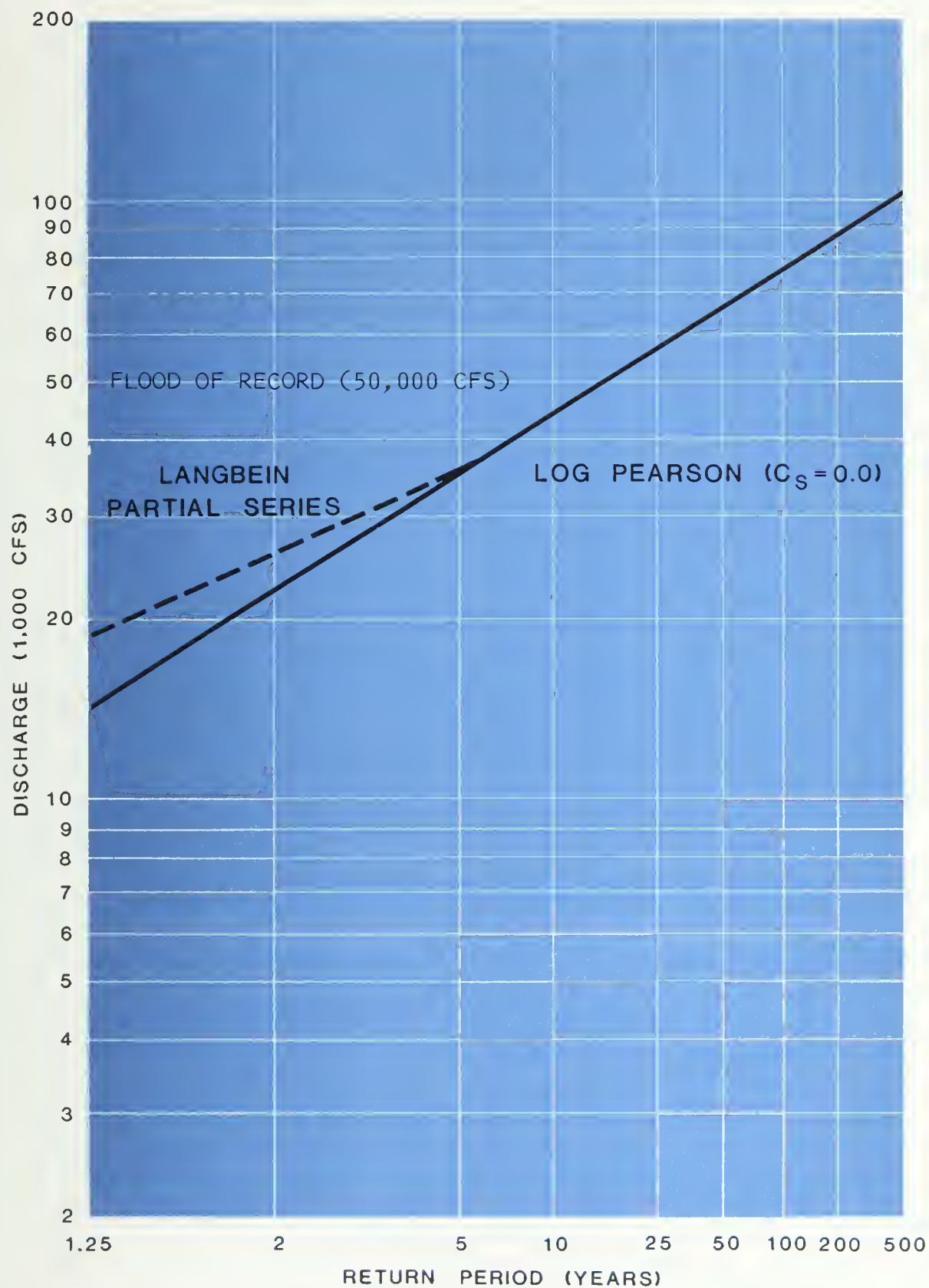
PLAN ELEMENT EVALUATION SUMMARY

EVALUATION OF ALTERNATIVE PLANS FOR ALLEVIATION
OF FLOOD DAMAGE, LOWER ROCK RIVER NEAR MOLINE

LAYOUT OF PLAN ELEMENTS

POTENTIAL OPEN-SPACE LAND USE

RECOMMENDED PLAN

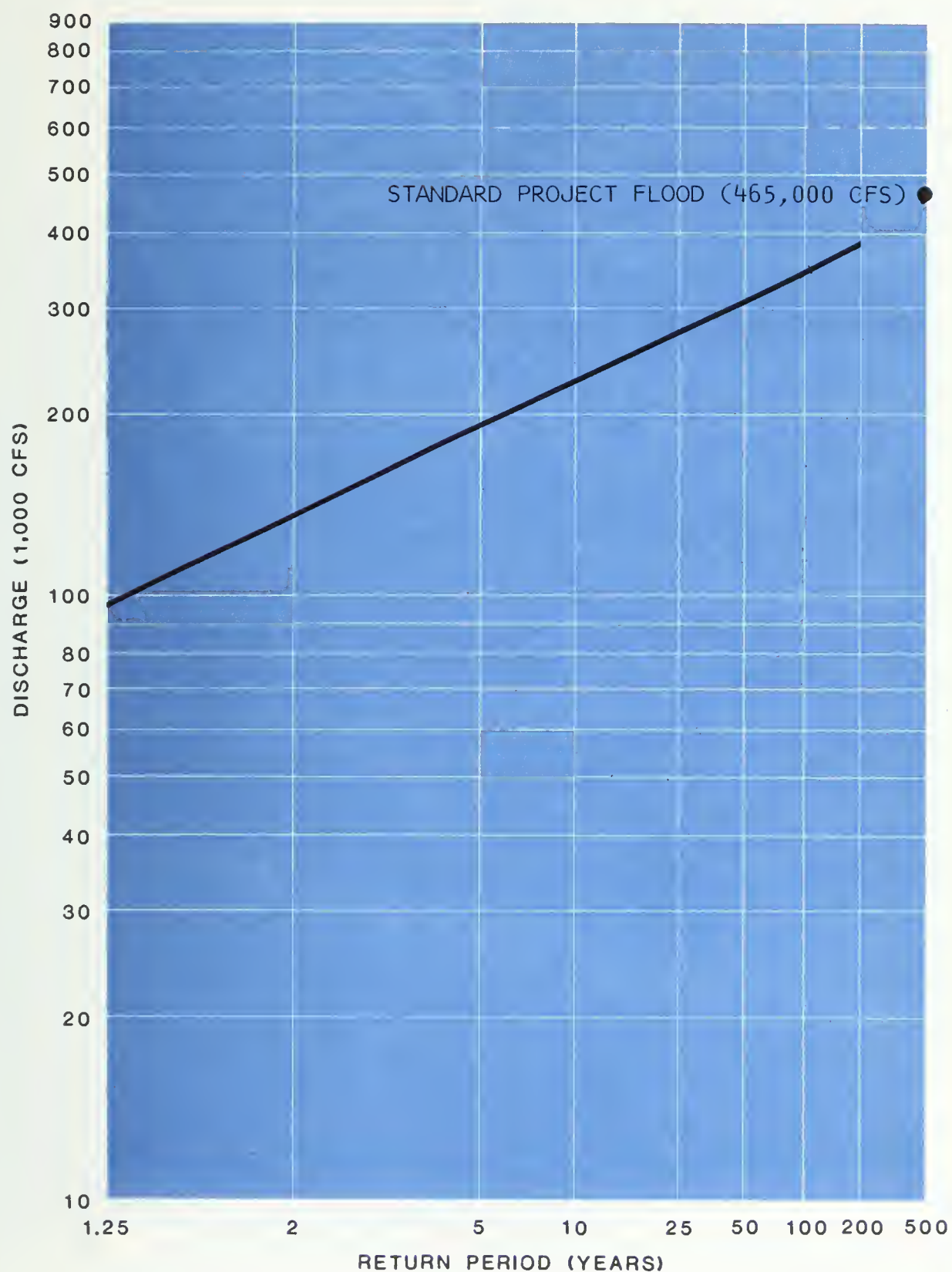


SOURCE: U.S. ARMY CORPS OF ENGINEERS,
ROCK ISLAND DISTRICT, AND HARZA

EXHIBIT 3

LOWER ROCK RIVER DISCHARGE-FREQUENCY RELATIONSHIP

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



SOURCE: U.S. ARMY CORPS OF ENGINEERS,
ROCK ISLAND DISTRICT

EXHIBIT 4

MISSISSIPPI RIVER DISCHARGE-FREQUENCY RELATIONSHIP

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



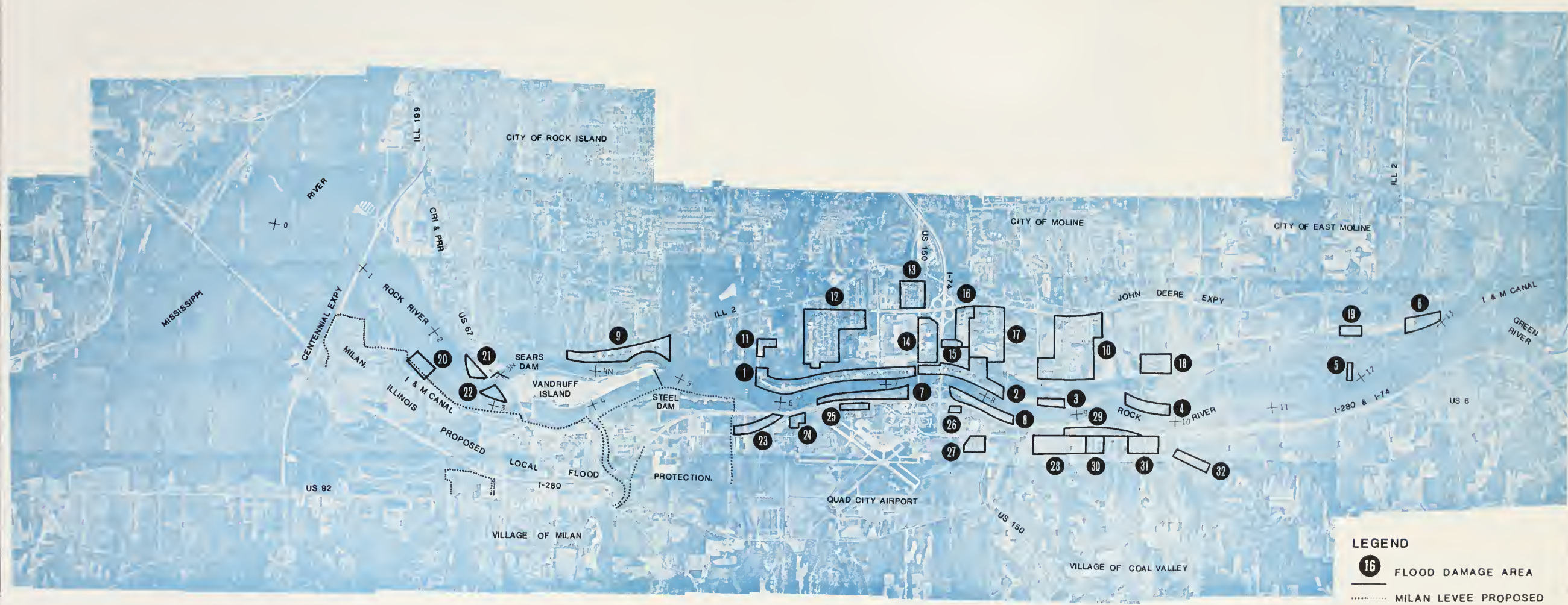
LEGEND

- 16 FLOOD DAMAGE AREA
- MILAN LEVEE PROPOSED BY U.S. ARMY CORPS OF ENGINEERS
- +
 RIVER MILE

EXHIBIT 2

FLOOD DAMAGE AREAS

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



LEGEND

- 16** FLOOD DAMAGE AREA
- MILAN LEVEE PROPOSED BY U.S. ARMY CORPS OF ENGINEERS
- + RIVER MILE

EXHIBIT 2

FLOOD DAMAGE AREAS

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY

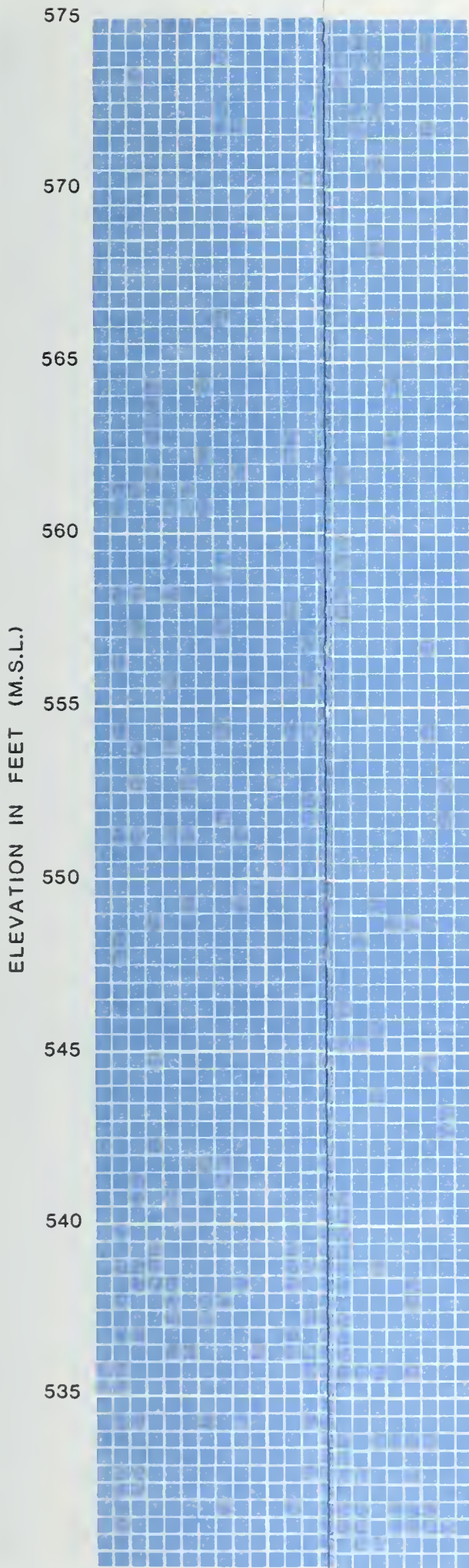
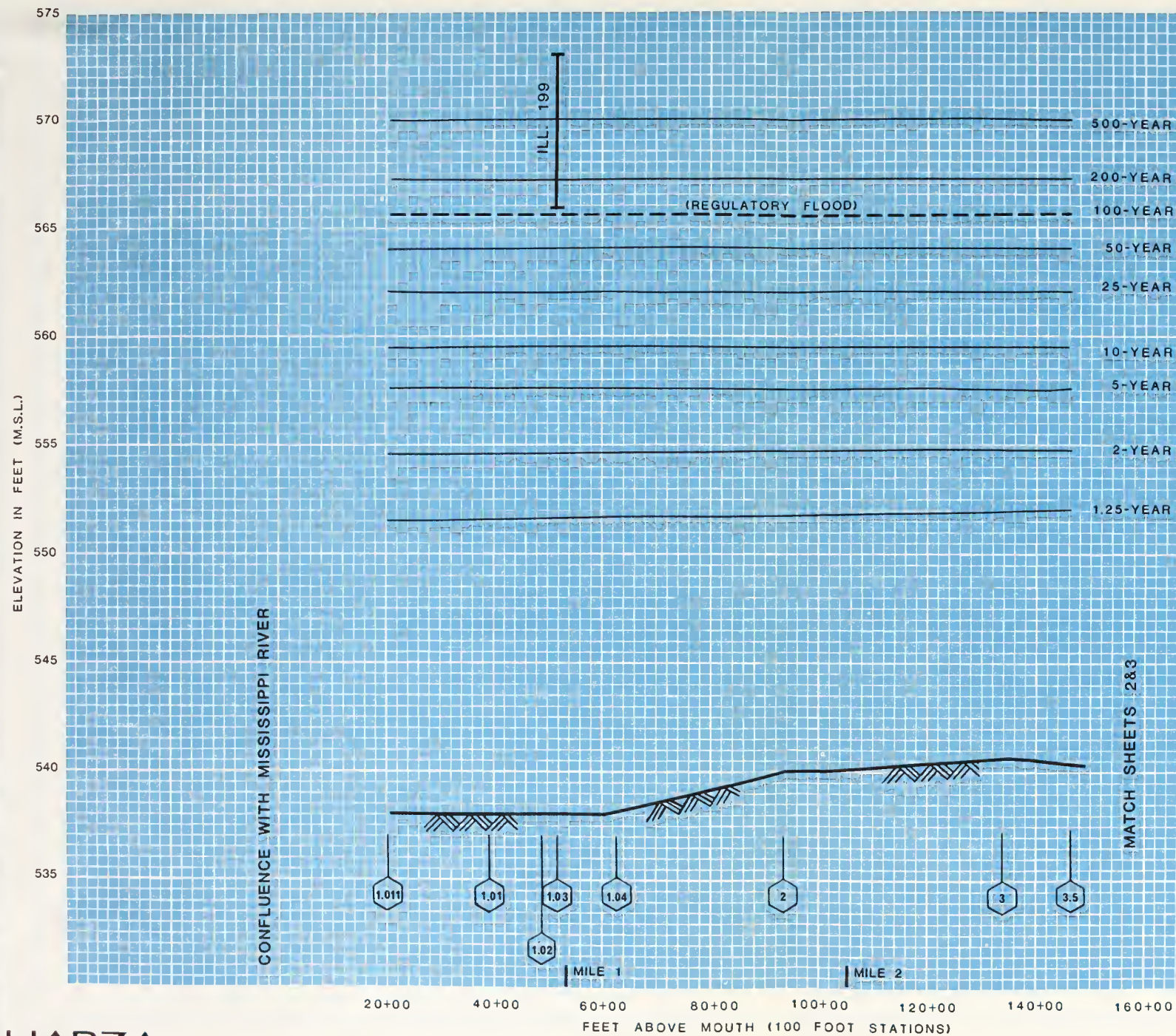


EXHIBIT 5

ROCK RIVER MAIN CHANNEL FLOOD PROFILES

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



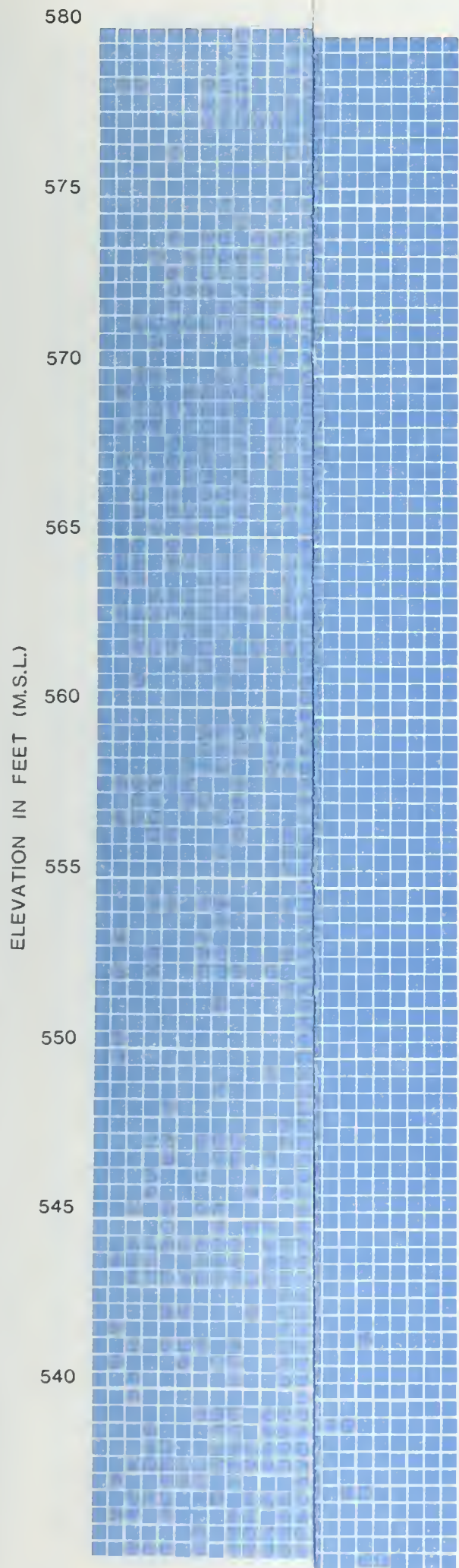
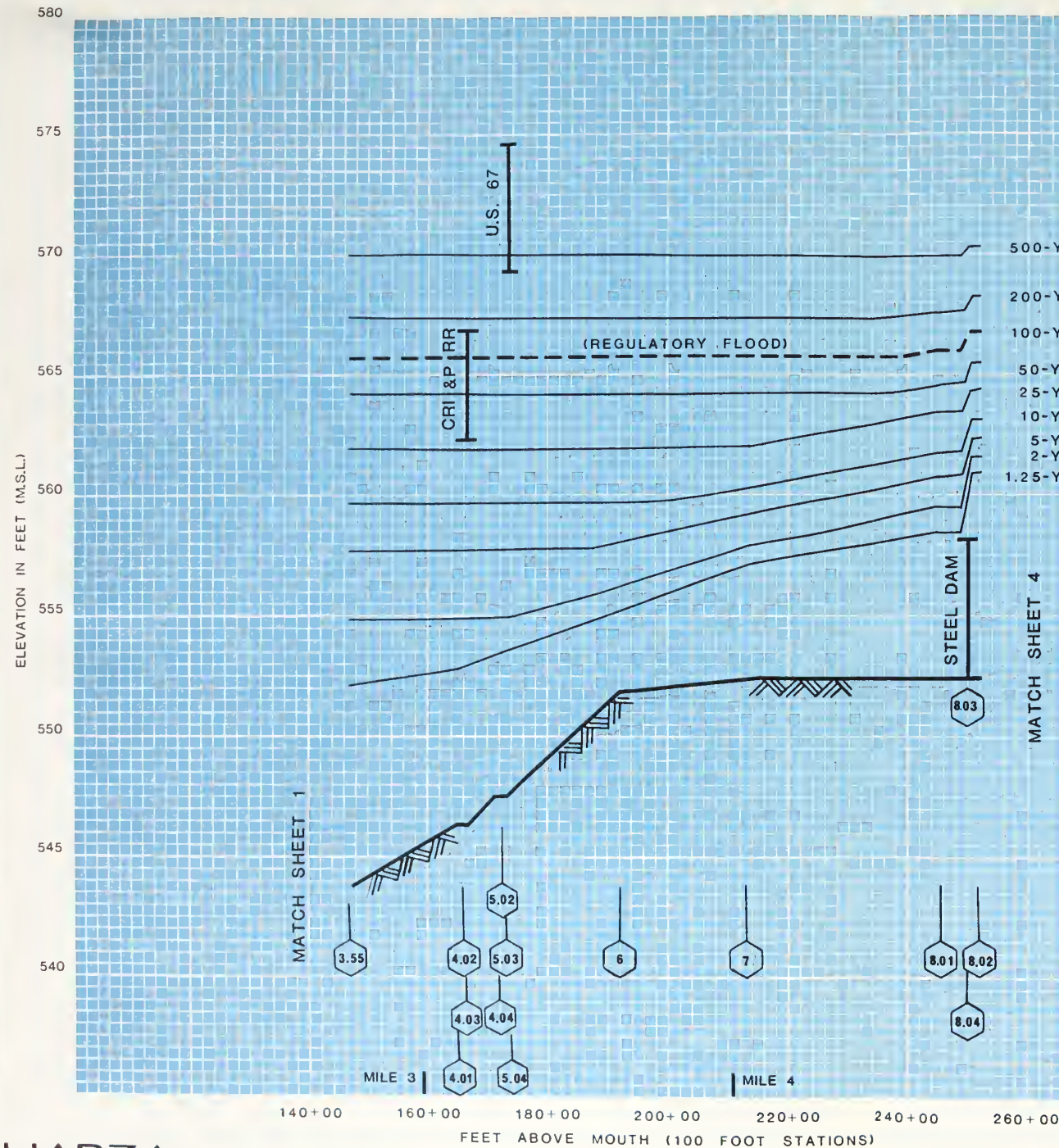
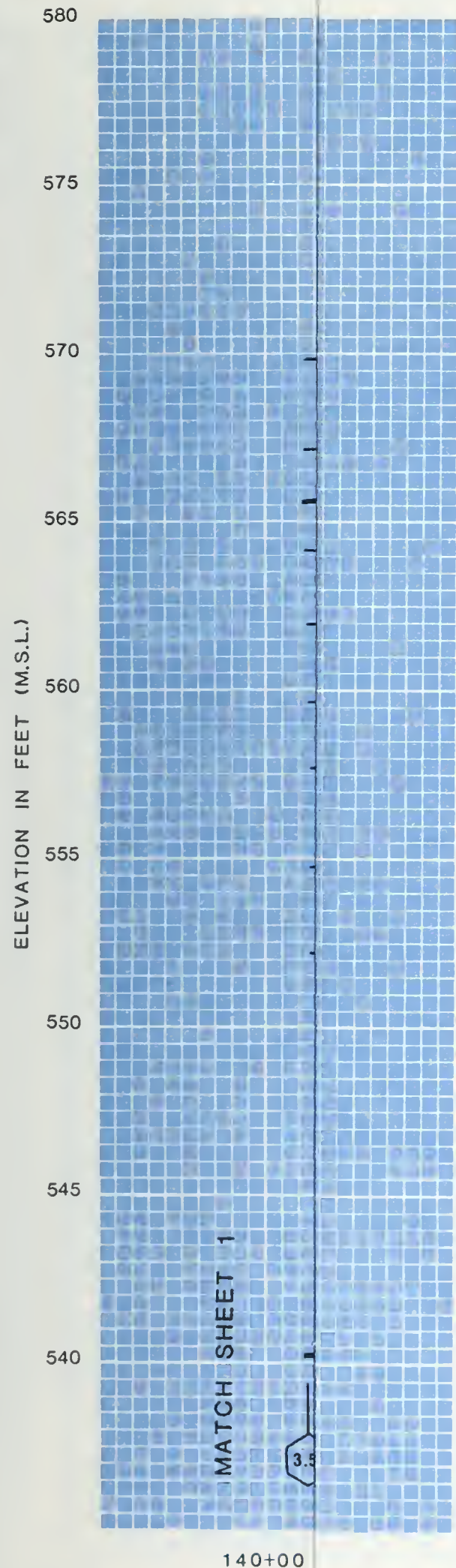


EXHIBIT 5

**ROCK RIVER
SOUTH CHANNEL
FLOOD PROFILES**

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY





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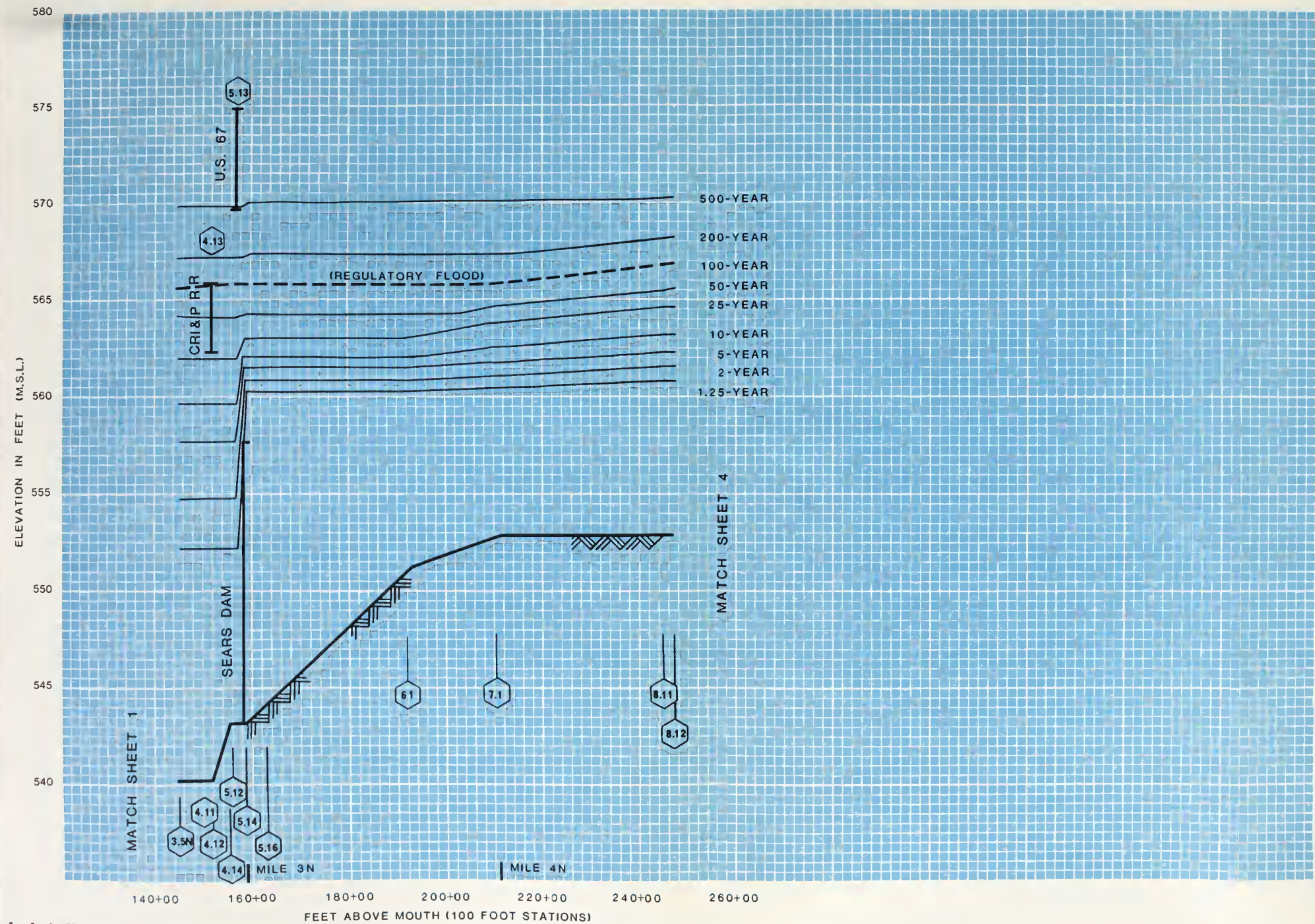
EXHIBIT 5

ROCK RIVER NORTH CHANNEL FLOOD PROFILES

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STRATEGIC PLANNING STUDY

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EXHIBIT 5
**ROCK RIVER
NORTH CHANNEL
FLOOD PROFILES**
LOWER ROCK RIVER
STRATEGIC PLANNING STUDY

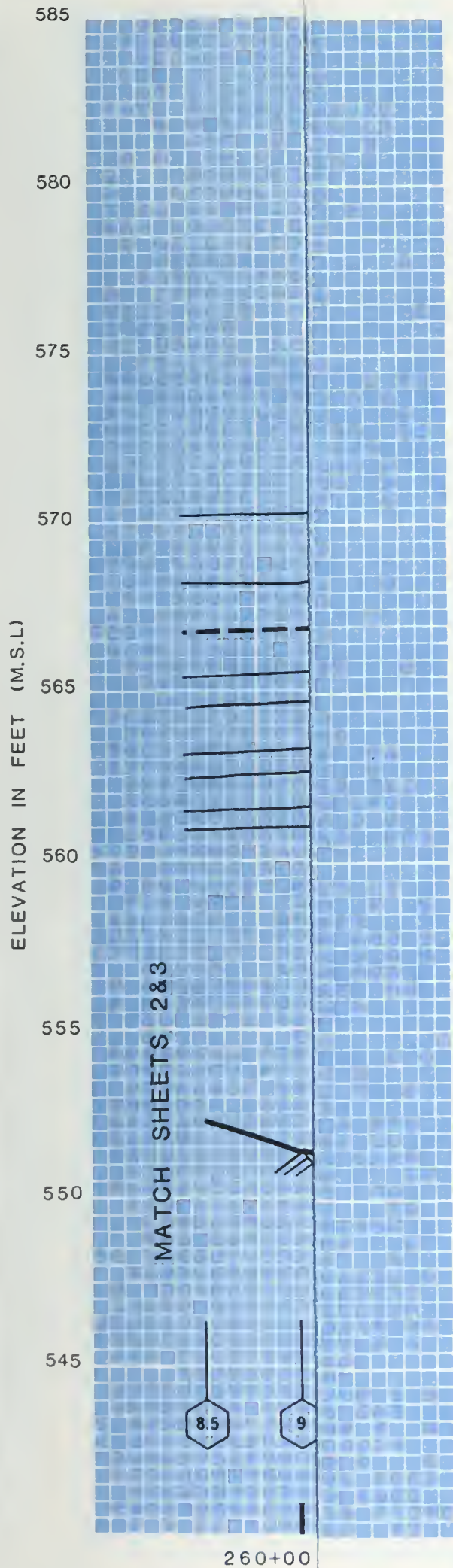
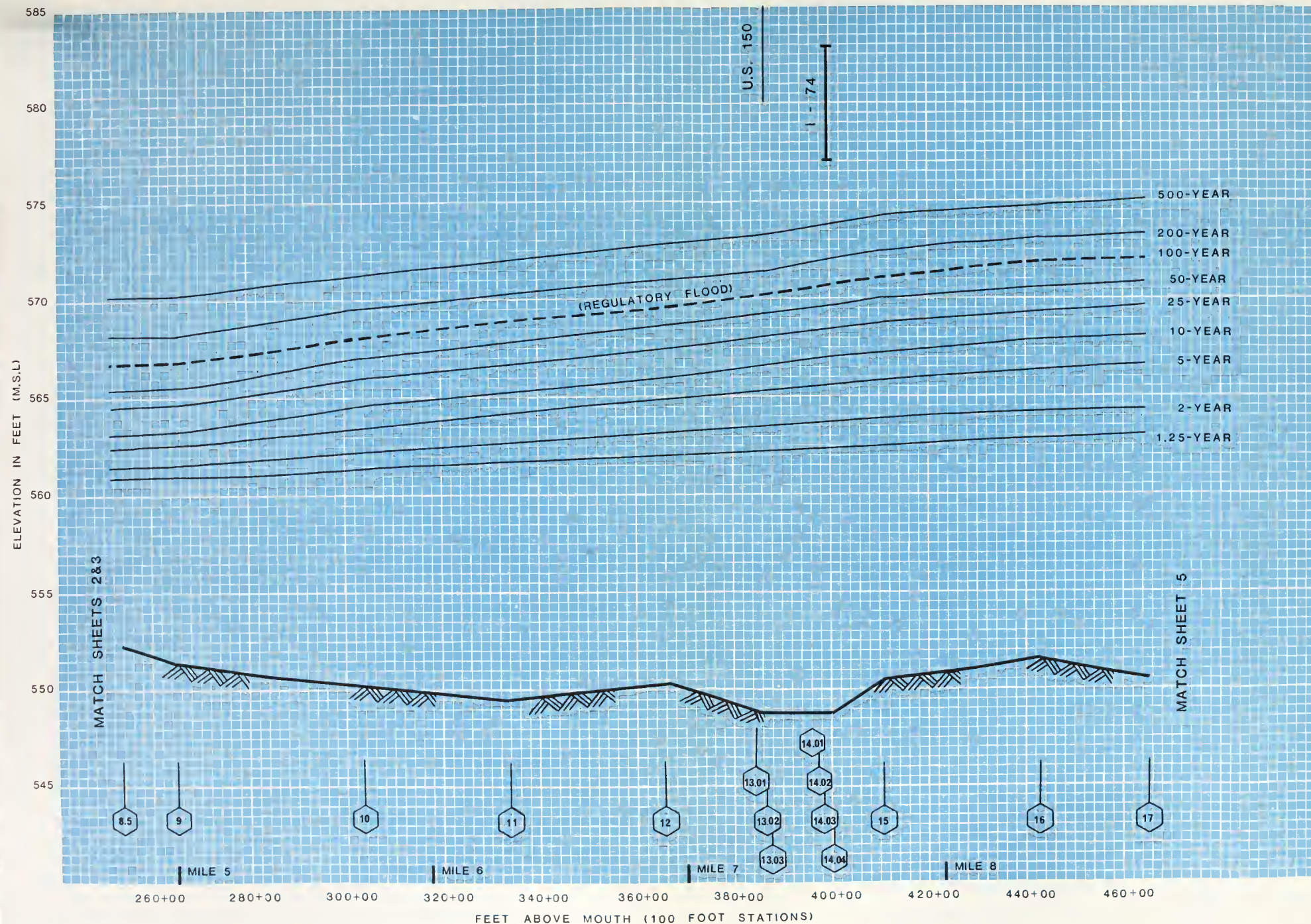


EXHIBIT 5

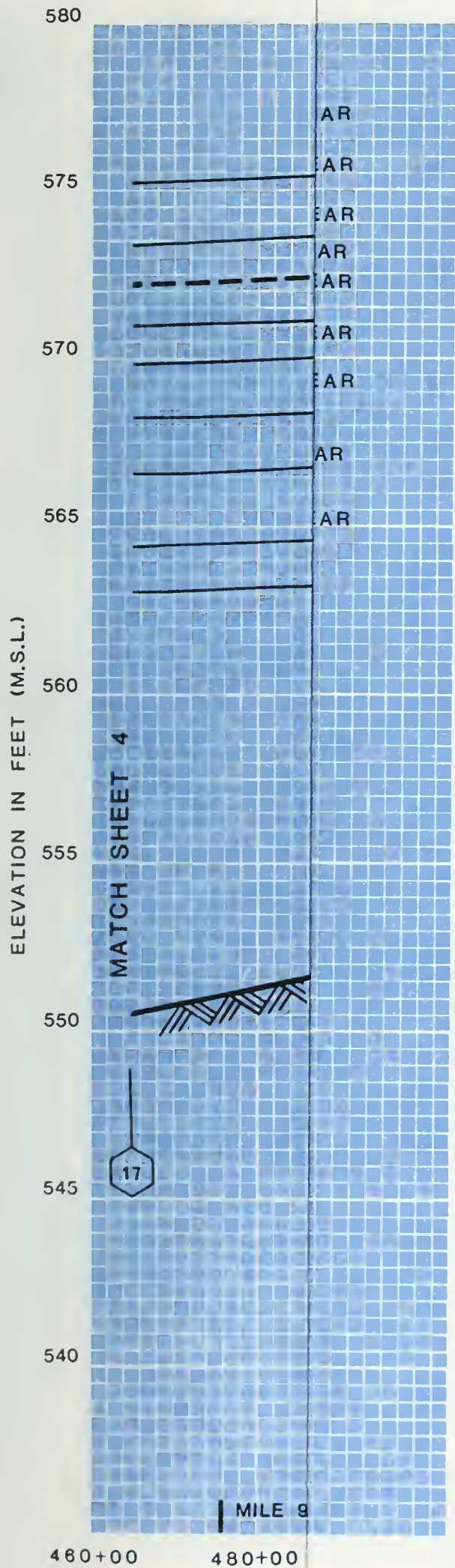
ROCK RIVER
MAIN CHANNEL
FLOOD PROFILES

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



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EXHIBIT 5
ROCK RIVER
MAIN CHANNEL
FLOOD PROFILES
 LOWER ROCK RIVER
 STRATEGIC PLANNING STUDY

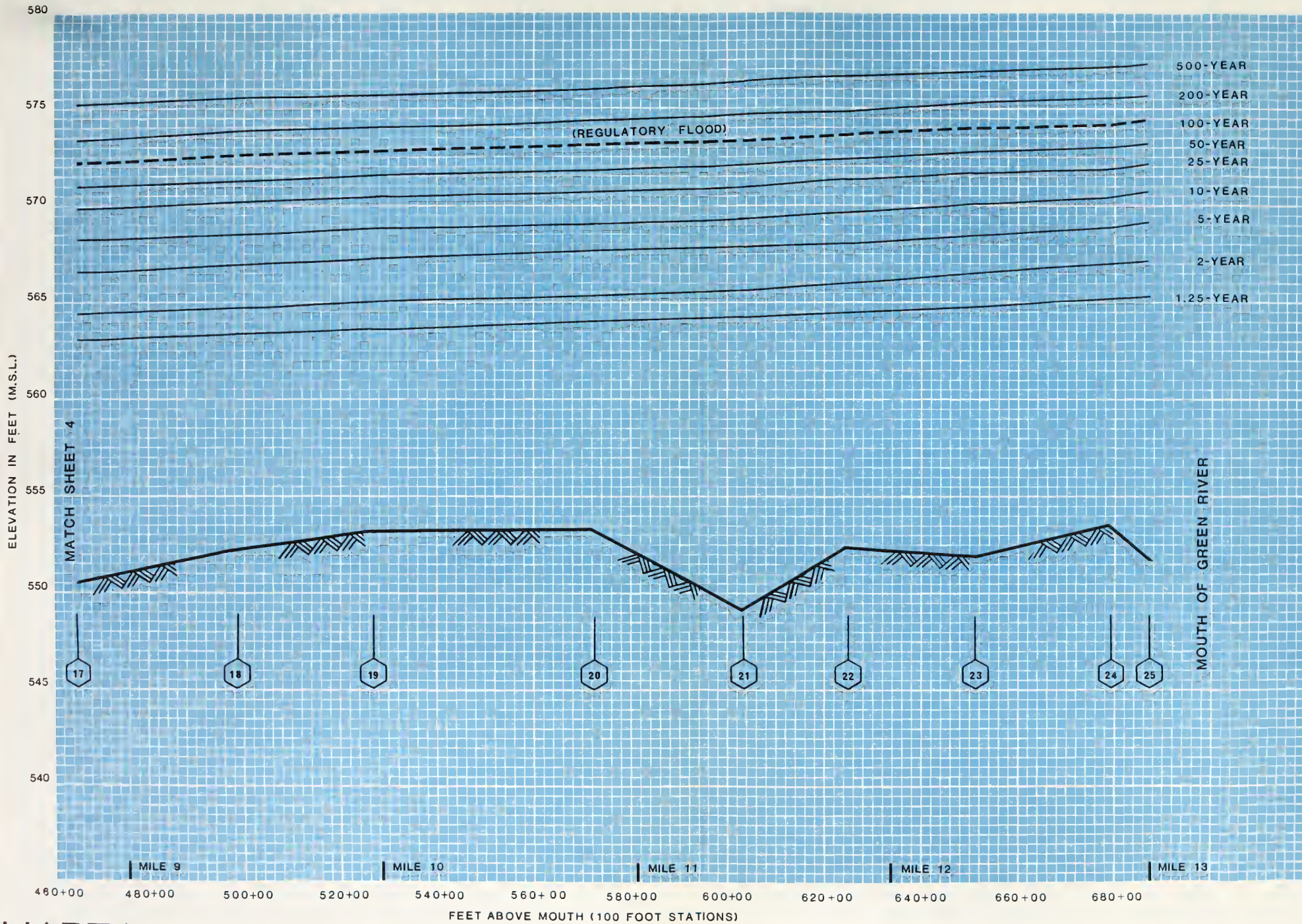


HARZA ENGINEERING

EXHIBIT 5

ROCK RIVER
MAIN CHANNEL
FLOOD PROFILES

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



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EXHIBIT 5
**ROCK RIVER
 MAIN CHANNEL
 FLOOD PROFILES**
 LOWER ROCK RIVER
 STRATEGIC PLANNING STUDY

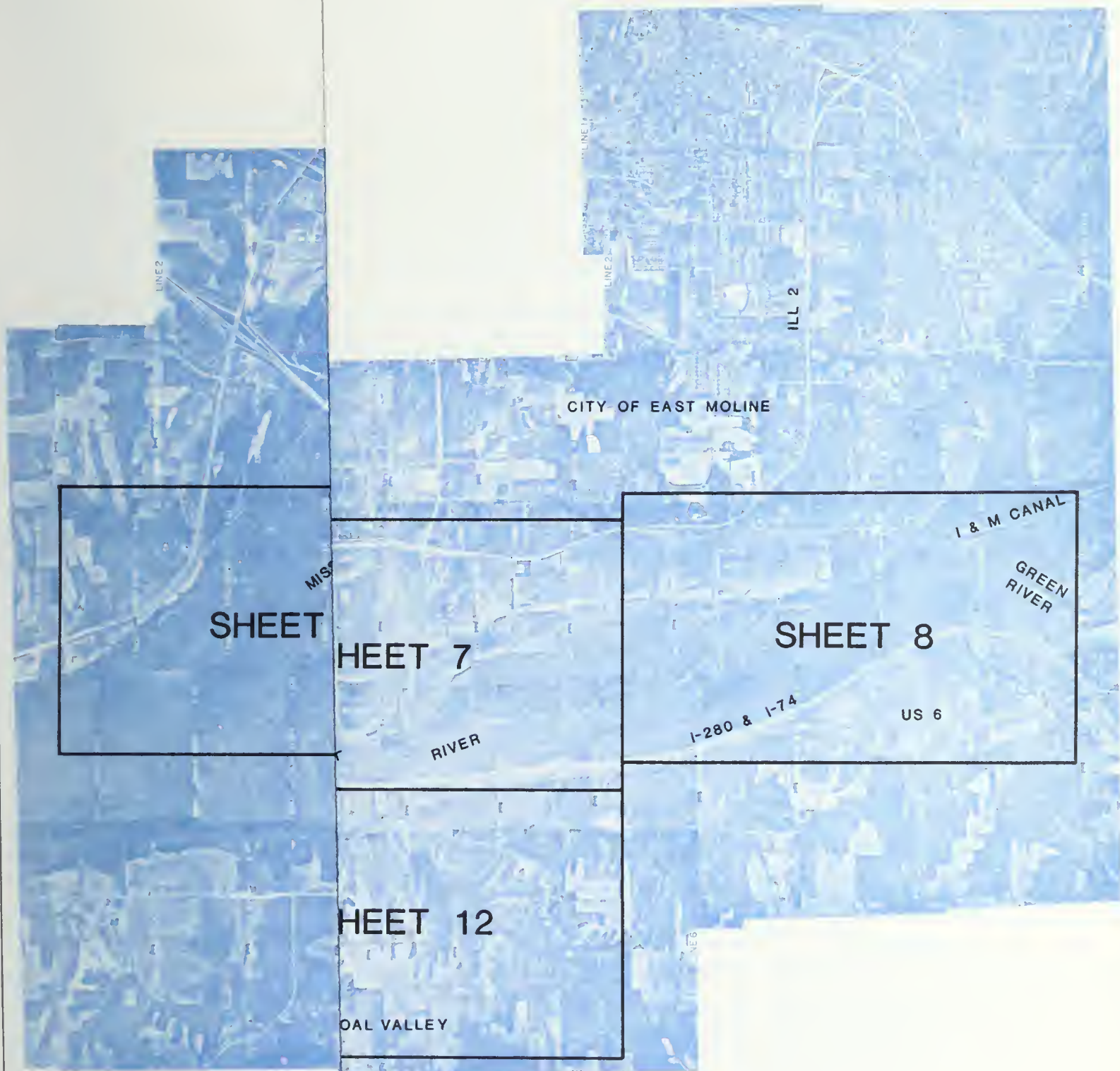


EXHIBIT 6

100-YEAR FLOOD INUNDATED AREA INDEX

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY

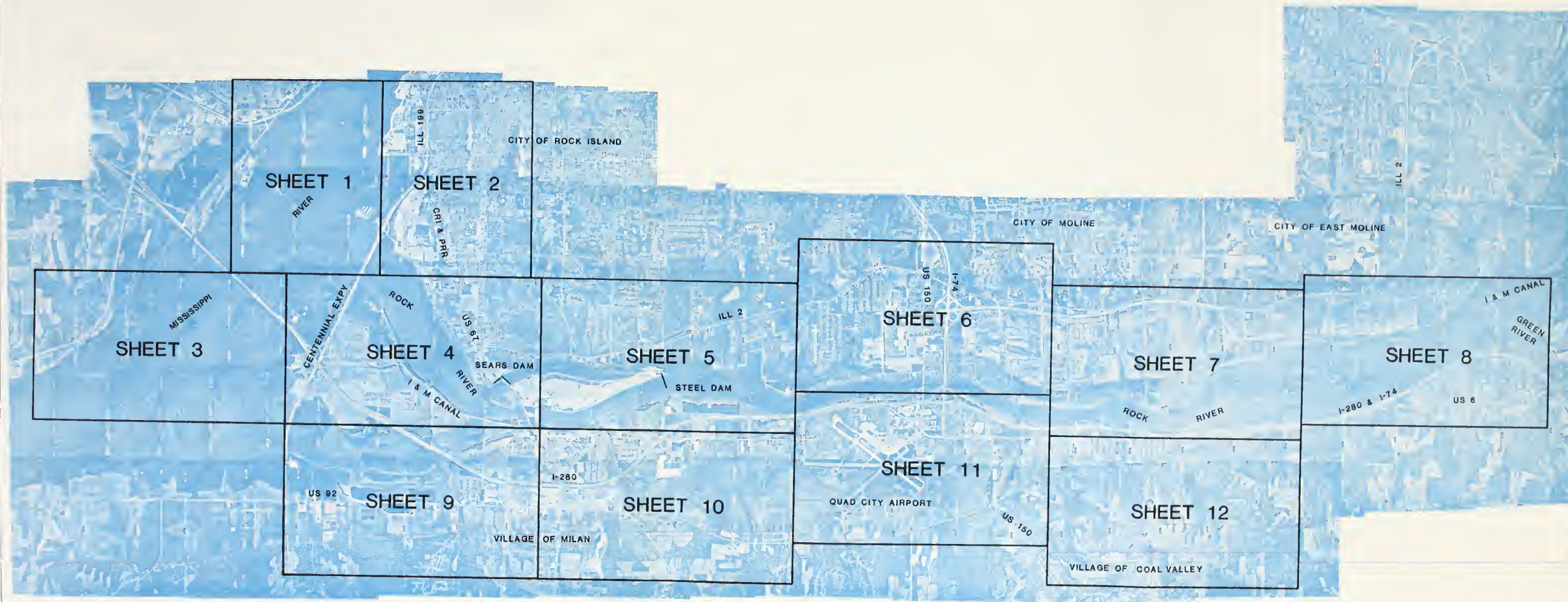
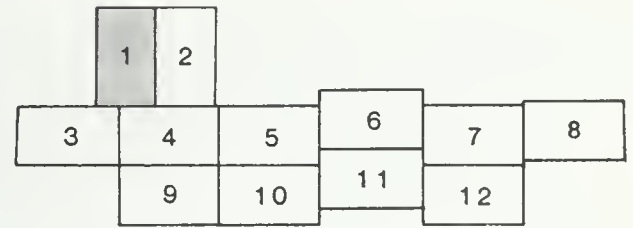


EXHIBIT 6

100-YEAR FLOOD INUNDATED AREA INDEX

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



SHEET INDEX

LEGEND



AREA INUNDATED BY
100-YEAR FLOOD

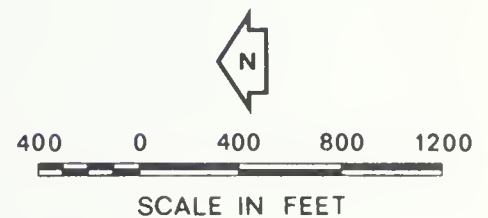
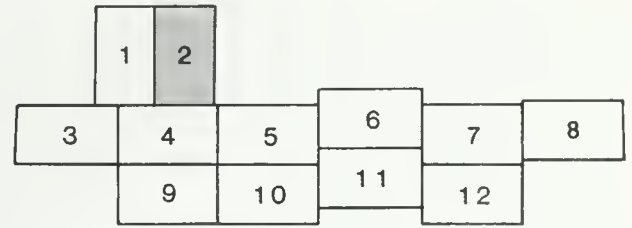
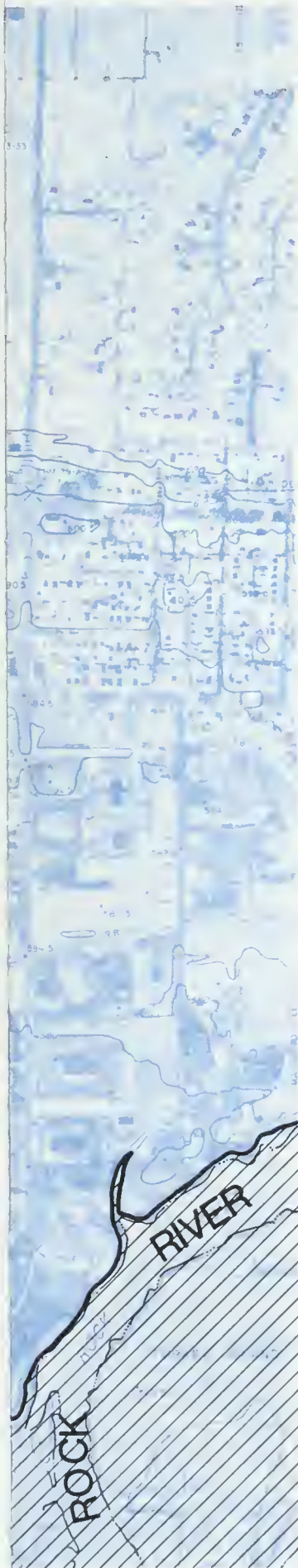


EXHIBIT 6

100-YEAR FLOOD INUNDATED AREA

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



SHEET INDEX

LEGEND



AREA INUNDATED BY
100-YEAR FLOOD

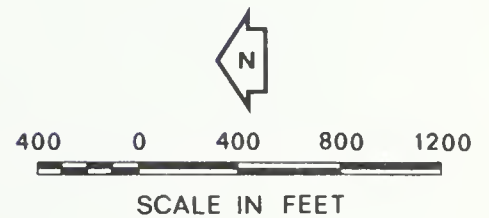
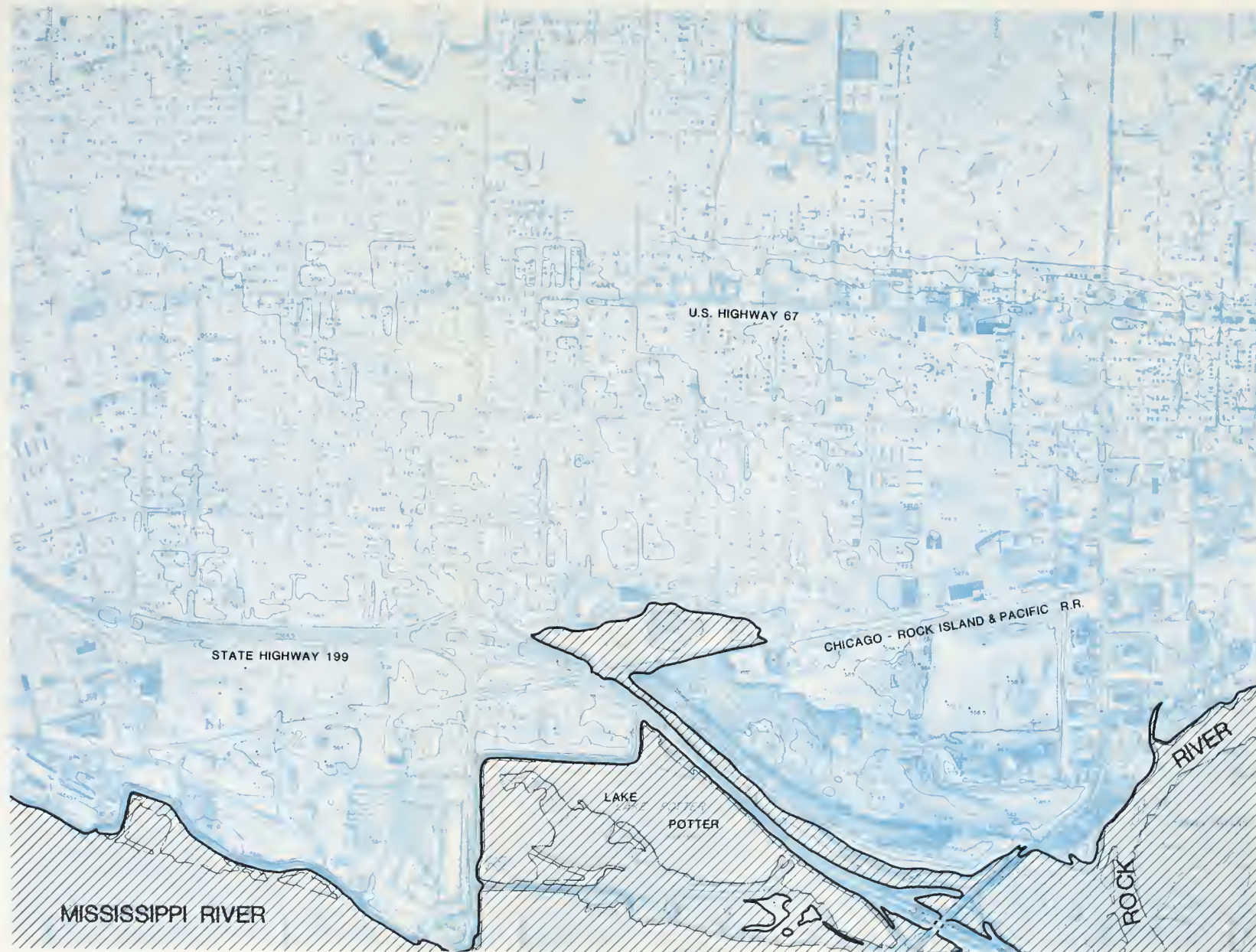


EXHIBIT 6

100-YEAR FLOOD INUNDATED AREA

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



	1	2					
3	4	5	6	7	8		
	9	10	11	12			

SHEET INDEX

LEGEND

 AREA INUNDATED BY 100-YEAR FLOOD

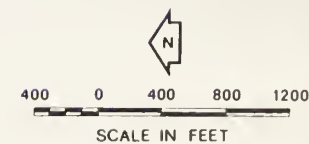
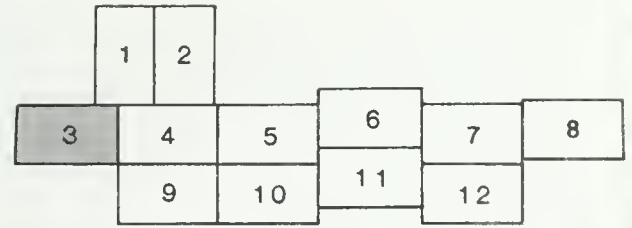


EXHIBIT 6
100-YEAR FLOOD
INUNDATED AREA
LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



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AREA INUNDATED BY
100-YEAR FLOOD



400 0 400 800 1200

SCALE IN FEET



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AREA INUNDATED BY
100-YEAR FLOOD

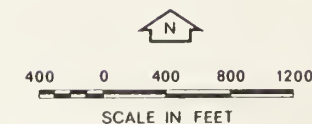
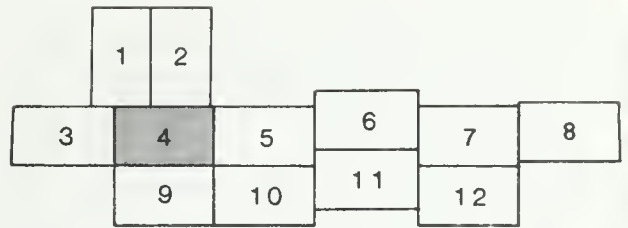
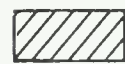


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100-YEAR FLOOD
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AREA INUNDATED BY
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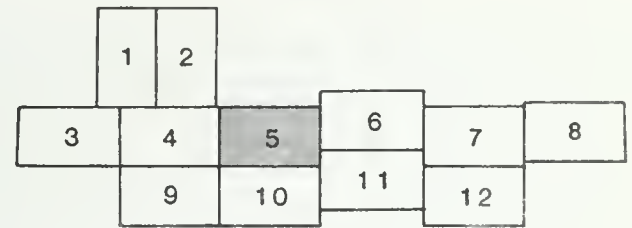
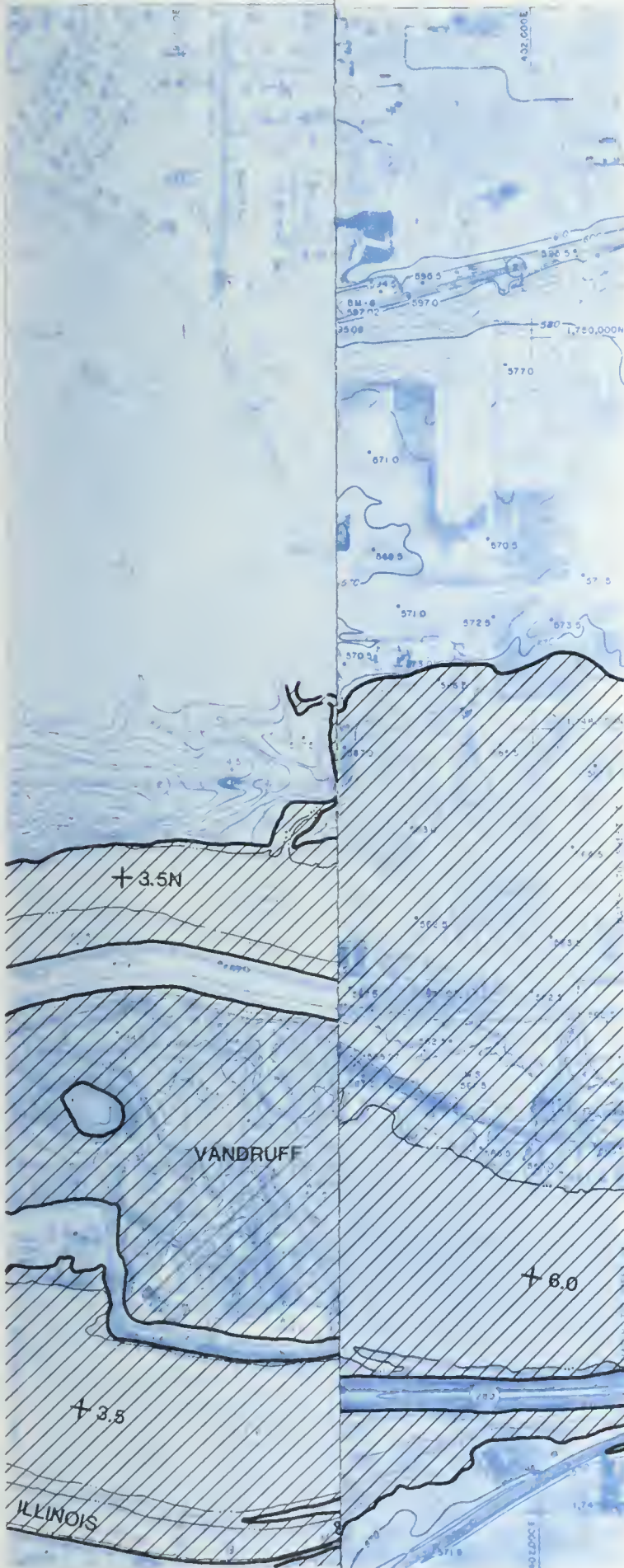
 AREA INUNDATED BY 100-YEAR FLOOD



400 0 400 800 1200

SCALE IN FEET

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 AREA INUNDATED BY 100-YEAR FLOOD

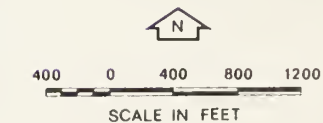
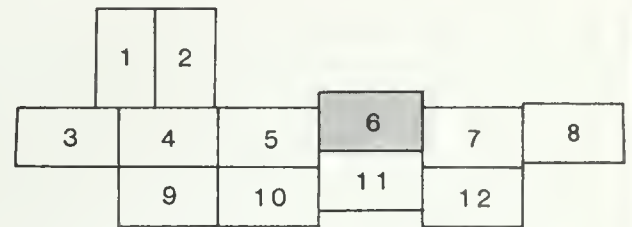


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100-YEAR FLOOD
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AREA INUNDATED BY
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 AREA INUNDATED BY 100-YEAR FLOOD

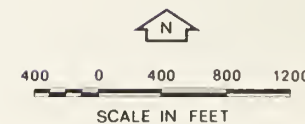
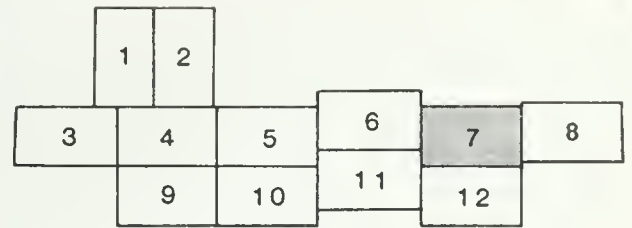
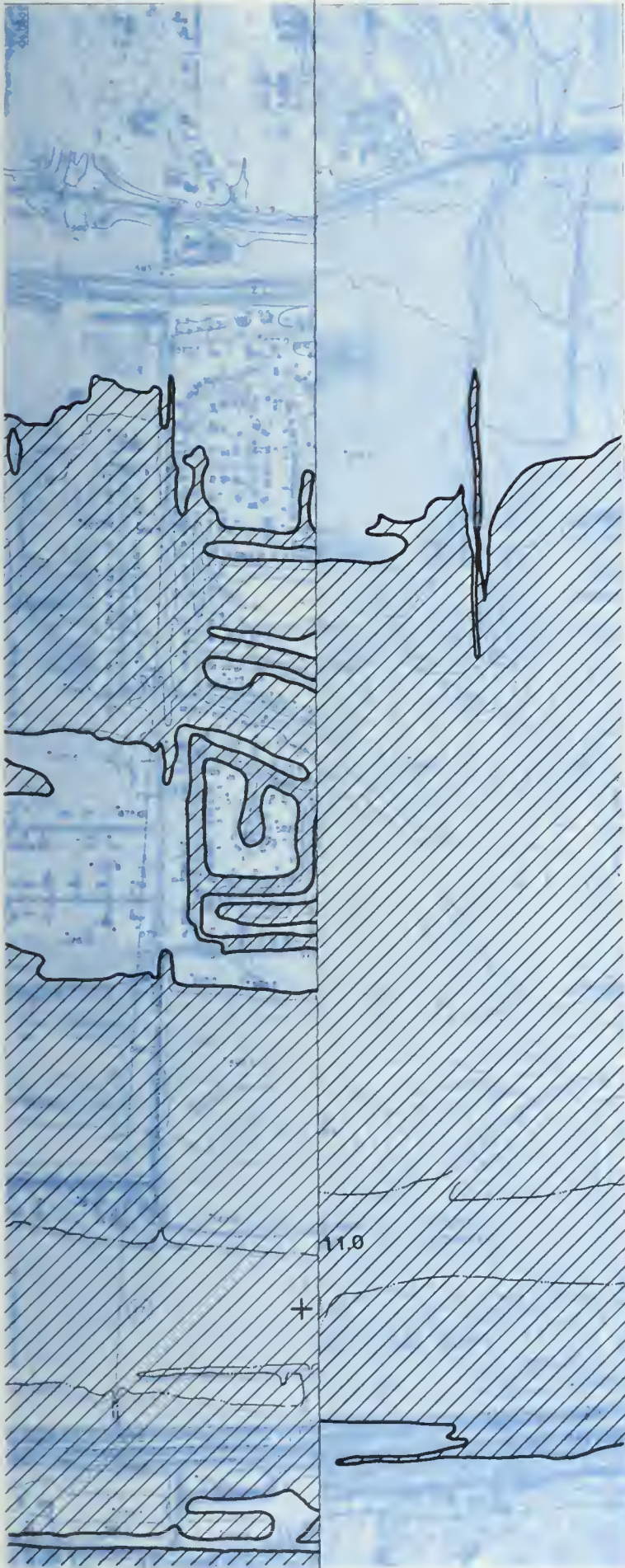


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LOWER ROCK RIVER
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AREA INUNDATED BY
100-YEAR FLOOD



400 0 400 800 1200

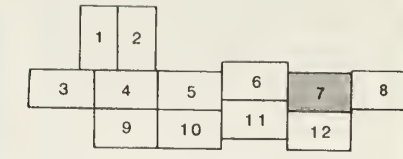
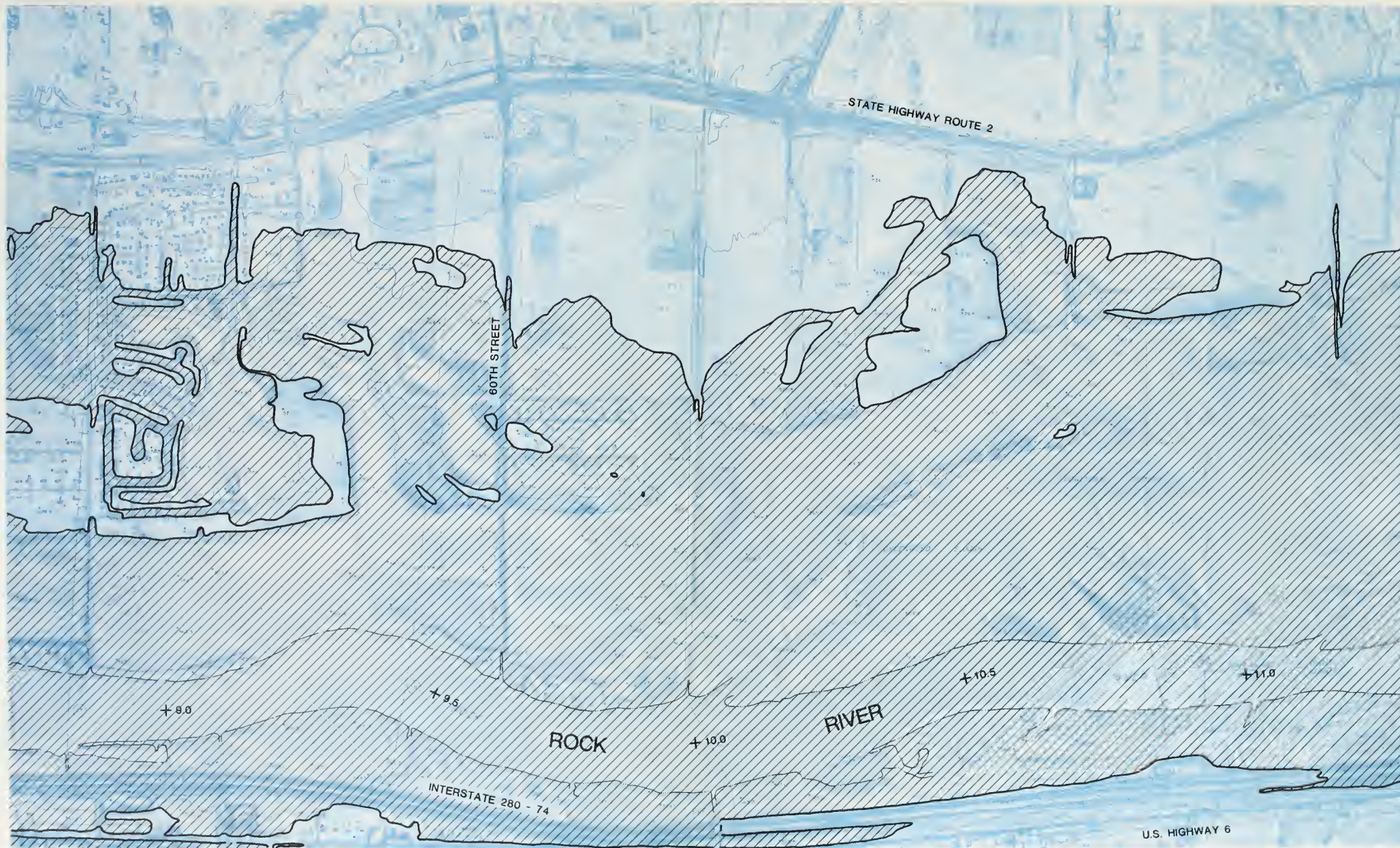


SCALE IN FEET

EXHIBIT 6


100-YEAR FLOOD INUNDATED AREA

LOWER ROCK RIVER
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 AREA INUNDATED BY 100-YEAR FLOOD

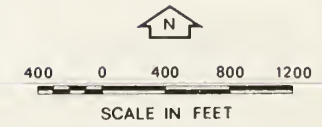
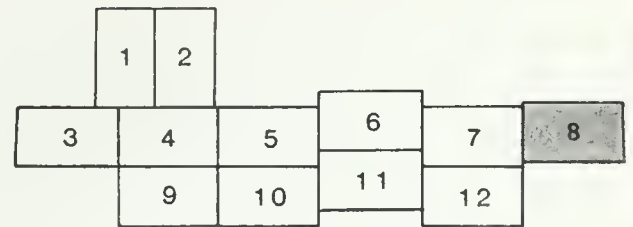


EXHIBIT 6
**100-YEAR FLOOD
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 LOWER ROCK RIVER
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AREA INUNDATED BY
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 AREA INUNDATED BY 100-YEAR FLOOD

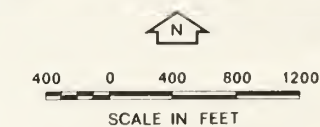
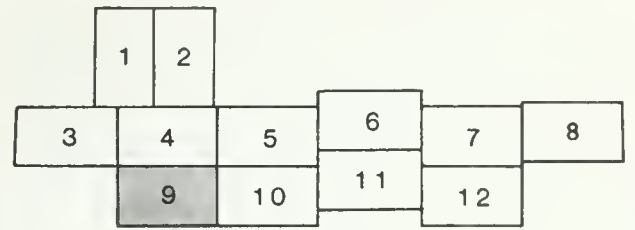
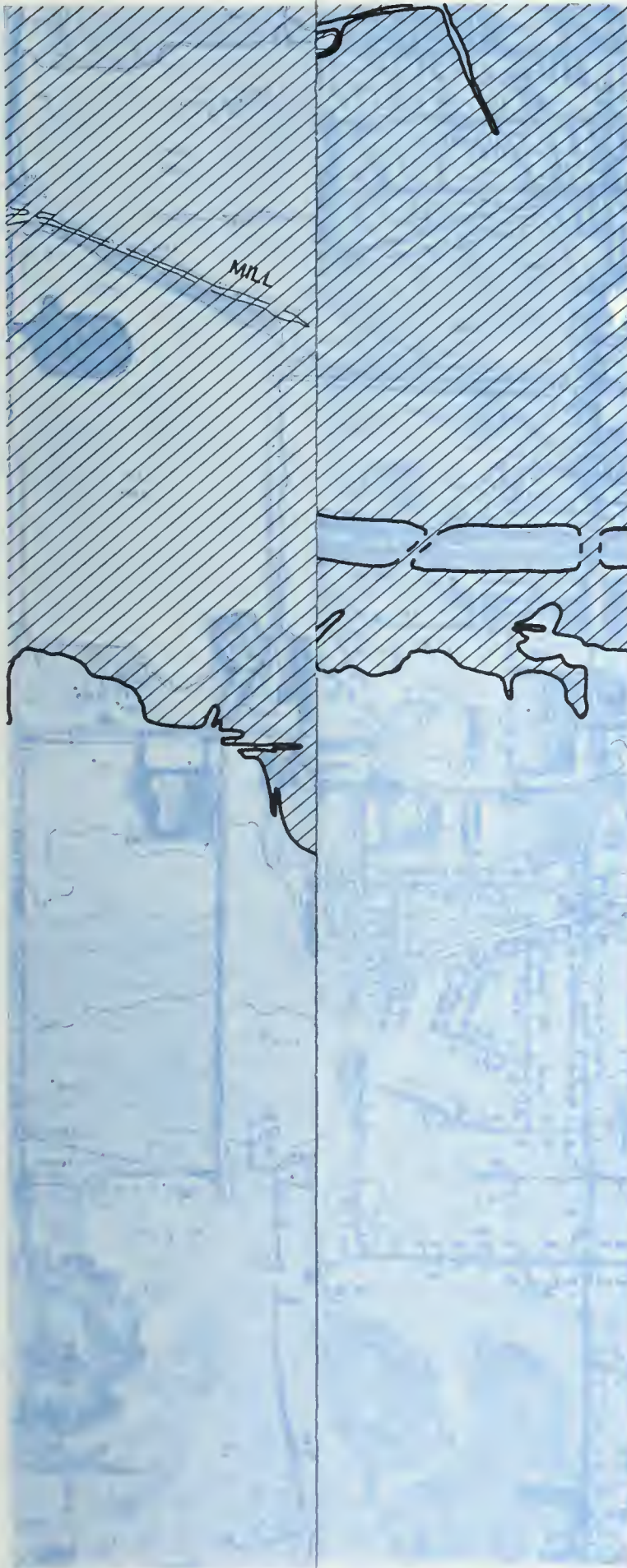


EXHIBIT 6
100-YEAR FLOOD
INUNDATED AREA
LOWER ROCK RIVER
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AREA INUNDATED BY
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 AREA INUNDATED BY 100-YEAR FLOOD

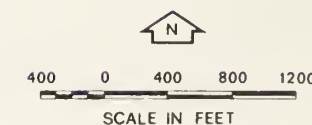
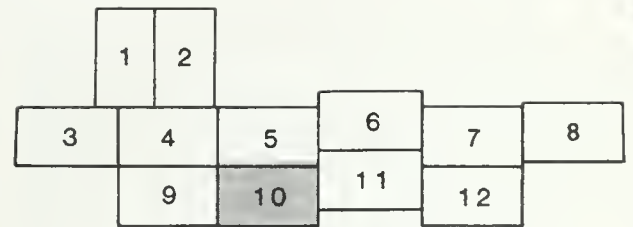
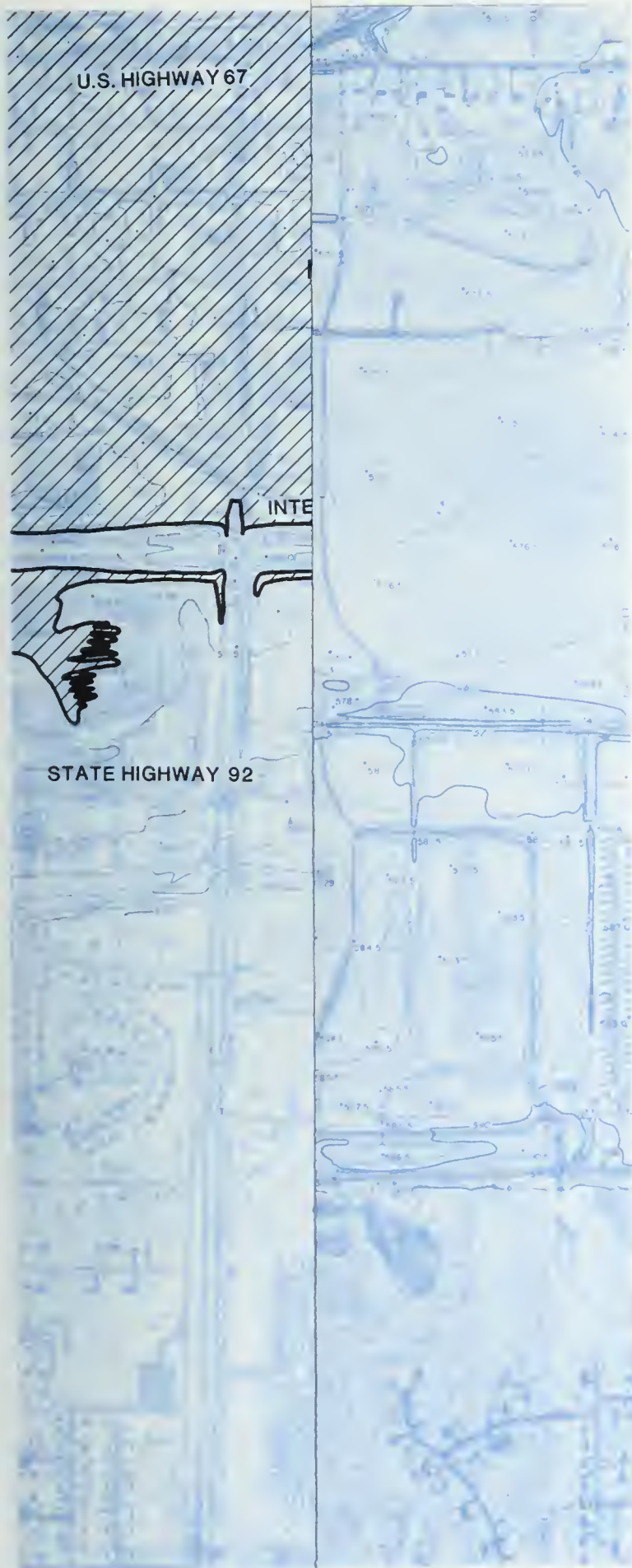


EXHIBIT 6 100-YEAR FLOOD INUNDATED AREA

LOWER ROCK RIVER
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AREA INUNDATED BY
100-YEAR FLOOD



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 AREA INUNDED BY 100-YEAR FLOOD

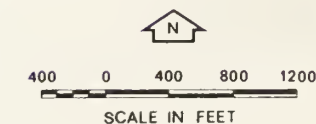
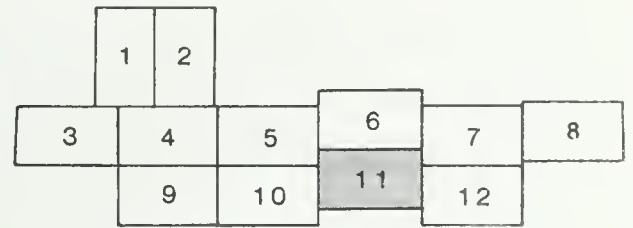
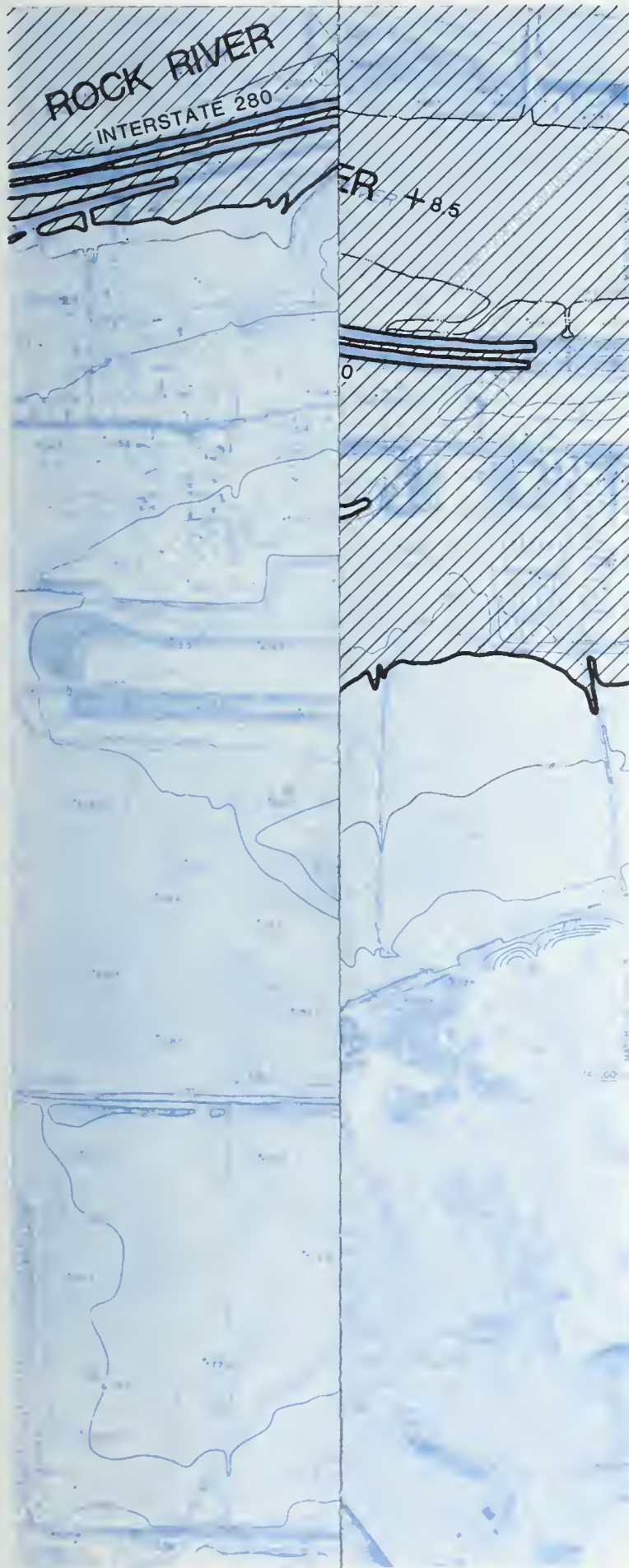


EXHIBIT 6

**100-YEAR FLOOD
INUNDED AREA**

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



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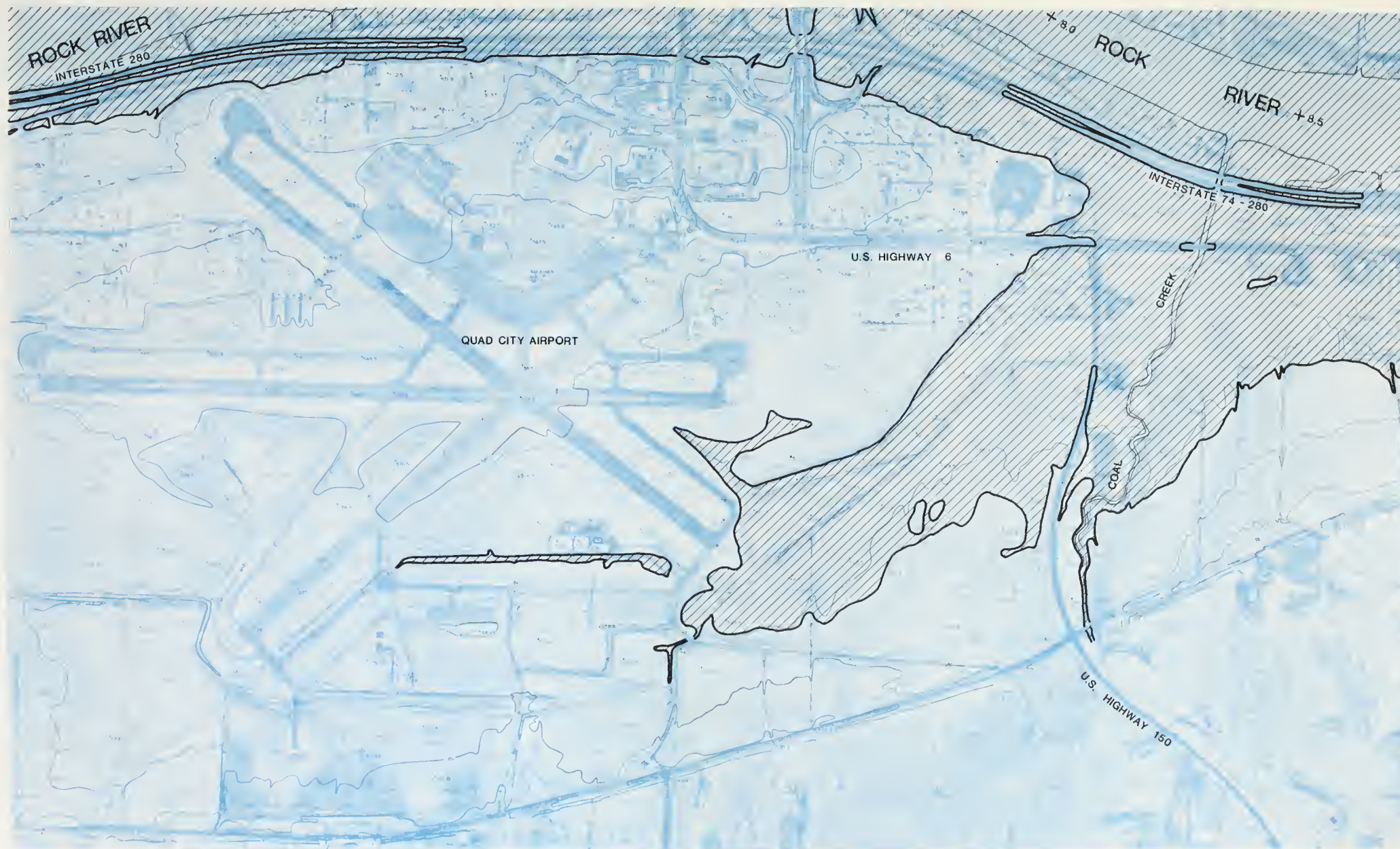


AREA INUNDATED BY
100-YEAR FLOOD



400 0 400 800 1200

SCALE IN FEET



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 AREA INUNDATED BY 100-YEAR FLOOD

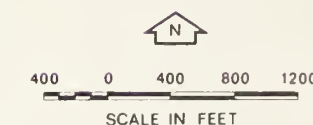
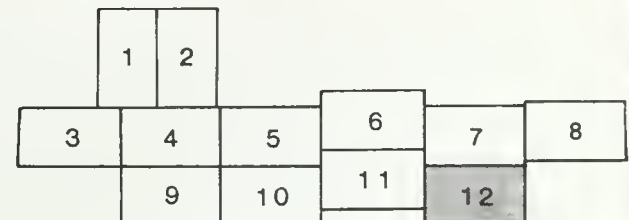


EXHIBIT 6
 100-YEAR FLOOD
 INUNDATED AREA
 LOWER ROCK RIVER
 STRATEGIC PLANNING STUDY



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 AREA INUNDATED BY 100-YEAR FLOOD

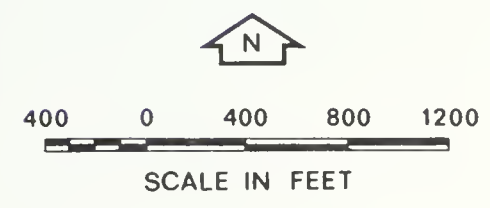
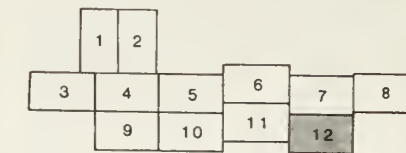


EXHIBIT 6

**100-YEAR FLOOD
INUNDATED AREA**

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



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 AREA INUNDATED BY 100-YEAR FLOOD

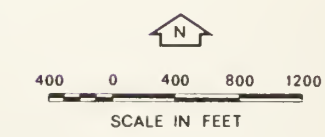


EXHIBIT 6
 100-YEAR FLOOD
 INUNDATED AREA
 LOWER ROCK RIVER
 STRATEGIC PLANNING STUDY



LEGEND

- RAISED ACCESS ROADS
- 15** LEVEE IDENTIFICATION NO.
- - - - - LEVEES OR FLOODWALLS
- + RIVER MILE

EXHIBIT 7

LOCATION OF PLAN ELEMENTS

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY

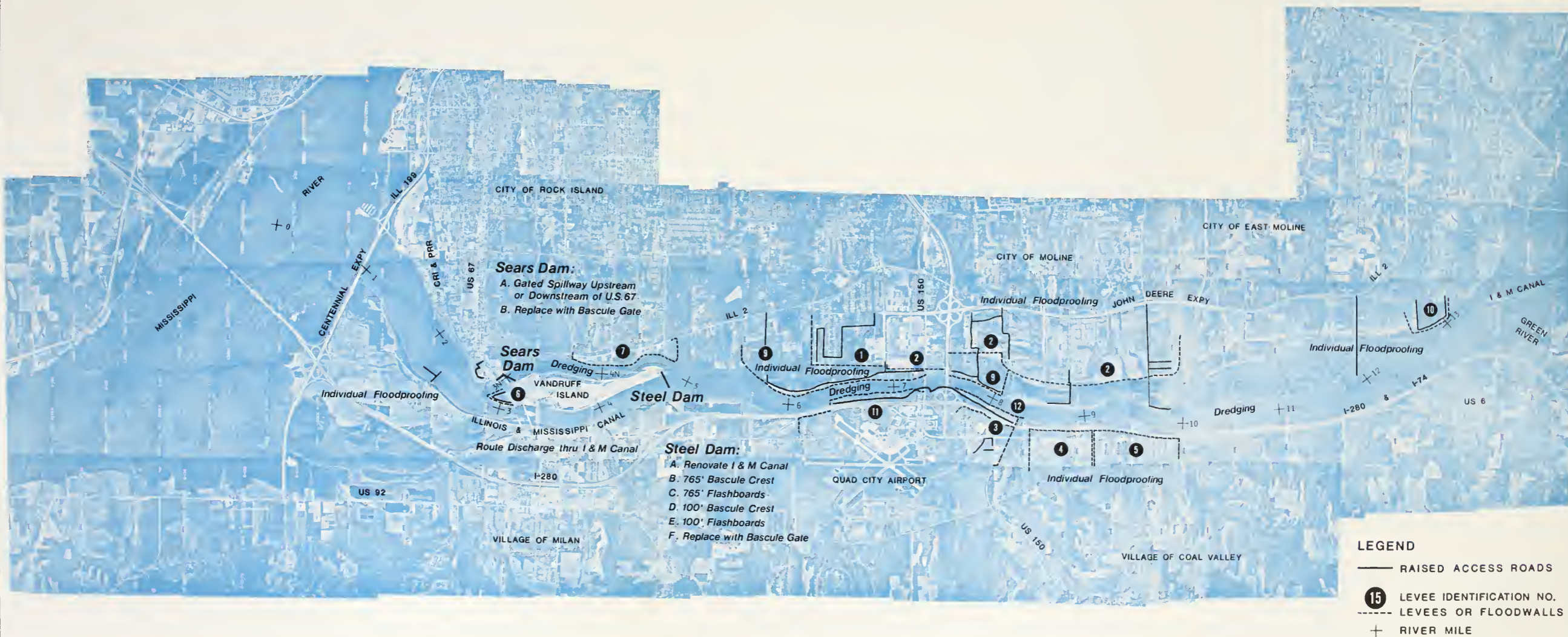


EXHIBIT 7

LOCATION OF PLAN ELEMENTS

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY

Y

<u>Present Worth Cost^{2/}</u>	<u>Average Annual Cost^{3/}</u>	<u>Reliability of Technical Performance</u>
935,000	109,000	Good
975,000	114,000	Good
,680,000	360,000	Good
641,000	95,400	Good
2,300,000	177,000	Good
3,720,000	285,000	Good
408,000	43,600	Good
564,000	60,300	Good
5,810,000	473,000	Uncertain
1,900,000	882,000	Uncertain
544,000	121,000	Uncertain
1,530,000	187,000	Uncertain
2,610,000	259,000	Uncertain

Exhibit 8

PLAN ELEMENT EVALUATION SUMMARY

<u>Alternative Plan Element</u>		<u>Capital^{1/} Cost^{2/}</u>	<u>Present Worth^{2/} Cost^{2/}</u>	<u>Average Annual^{3/} Cost^{3/}</u>	<u>Reliability of Technical Performance</u>
1.	Sears Dam, Gated Spillway Downstream from U.S. 67	935,000	935,000	109,000	Good
2.	Sears Dam, Gated Spillway Upstream from U.S. 67	975,000	975,000	114,000	Good
3.	Sears Dam Full-length, 13-foot high Bascule Gate	4,680,000	4,680,000	360,000	Good
4.	Steel Dam, 765-foot Lowered Spillway by 3 feet with Hinged Flashboards	641,000	641,000	95,400	Good
5.	Steel Dam, 765-foot Lowered Spillway by 3 feet with Bascule Gate	2,300,000	2,300,000	177,000	Good
6.	Steel Dam, Replaced with 765-foot long, 6-foot high Bascule Gate	3,720,000	3,720,000	285,000	Good
7.	Steel Dam, Renovated Tainter Gates Discharging through the Illinois and Mississippi Canal to the Rock River just downstream of Steel Dam	408,000	408,000	43,600	Good
8.	Steel Dam, Renovated Tainter Gates Discharging through the Illinois and Mississippi Canal to the Rock River at Mill Creek	564,000	564,000	60,300	Good
9.	Dredging Rock River from Sears and Steel Dams to Green River, approximately 1-1/2 feet	5,810,000	5,810,000	473,000	Uncertain
10.	Dredging Rock River from Sears and Steel Dams to Green River, approximately 3 feet	11,900,000	11,900,000	882,000	Uncertain
11.	Dredging North Channel of Rock River from Sears Dam to Carr Island, approximately 1-1/2 feet	544,000	544,000	121,000	Uncertain
12.	Dredging North Channel of Rock River from Sears Dam to Carr Island, approximately 3 feet	1,530,000	1,530,000	187,000	Uncertain
13.	Dredging Rock River from Sears and Steel Dams to Heritage Addition, approximately 1-1/2 feet	2,610,000	2,610,000	259,000	Uncertain

ARY

Present Worth Cost ^{2/}	Average Annual Cost ^{3/}	Reliability of Technical Performance
90,000	445,000	Uncertain
10,000	44,700	Excellent
15,000	15,700	Excellent
13,000	8,270	Excellent
01,000	7,720	Excellent
97,300	7,250	Excellent
50,000	10,200	Excellent
55,000	51,000	Excellent
00,000	67,500	Excellent
30,000	29,000	Excellent
500,000	175,000	Excellent
870,000	92,100	Excellent

PLAN ELEMENT EVALUATION SUMMARY

<u>Alternative Plan Element</u>	<u>Capital Cost^{2/}</u>	<u>Present Worth^{3/} Cost^{2/}</u>	<u>Average Annual^{3/} Cost^{2/}</u>	<u>Reliability of Technical Performance</u>
14. Dredging Rock River from Sears and Steel Dams to Heritage Addition, approximately 3 feet	5,390,000	5,390,000	445,000	Uncertain
15. Levee to Protect Damage Areas 10, 14, 15, 16, 17, 18	610,000	610,000	44,700	Excellent
16. Levee to Protect Damage Area 28	215,000	215,000	15,700	Excellent
17. Levee to Protect Damage Area 12	113,000	113,000	8,270	Excellent
18. Levee to Protect Damage Area 26 and 27	101,000	101,000	7,720	Excellent
19. Levee to Protect Damage Areas 29, 30, 31	97,300	97,300	7,250	Excellent
20. Levee to Protect Damage Area 22	150,000	150,000	10,200	Excellent
21. Levee - Floodwall to Protect Damage Area 6	755,000	755,000	51,000	Excellent
22. Levee - Floodwall to Protect Damage Area 7	1,000,000	1,000,000	67,500	Excellent
23. Levee - Floodwall to Protect Damage Area 9	430,000	430,000	29,000	Excellent
24. Levee - Floodwall to Protect Damage Areas 1, 11, 12, 13	2,600,000	2,600,000	175,000	Excellent
25. Levee - Floodwall to Protect Damage Areas 8, 26	1,370,000	1,370,000	92,100	Excellent

MARY

<u>Present Worth Cost^{2/}</u>	<u>Average Annual Cost^{3/}</u>	<u>Reliability of Technical Performance</u>
540,000	106,000	Excellent
930,000	196,100	Good
416,000	94,700	Good
010,000	268,000	Good
300,000 ^{4/}	892,000	Excellent
380,000 ^{4/}	660,000	Excellent
973,100 ^{4/}	267,000	Very Good

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Exhibit 8 (Cont'd)

PLAN ELEMENT EVALUATION SUMMARY

<u>Alternative Plan Element</u>	<u>Capital Cost^{1/}</u>	<u>Present Worth^{2/} Cost^{2/}</u>	<u>Average Annual^{3/} Cost^{3/}</u>	<u>Reliability of Technical Performance</u>
26. Levee - Floodwall to Protect Damage Areas 2, 10, 14, 15, 16, 17, 18	1,540,000	1,540,000	106,000	Excellent
27. Flood proofing to 100-year Flood Level, All Structures	2,874,000	2,930,000	196,100	Good
28. Flood proofing to 100-year Flood Level, Structures not Protected by Levees	1,408,000	1,416,000	94,700	Good
29. Raising Access Roads to 100-year Flood Level	4,010,000	4,010,000	268,000	Good
30. Evacuation of the Floodway and Adjacent Floodway Fringe Areas	18,500,000	13,300,000 ^{4/}	892,000	Excellent
31. Evacuation of the Floodway	13,700,000	9,880,000 ^{4/}	660,000	Excellent
32. Recreational Facilities for Cleared Floodway	1,112,000	973,100 ^{4/}	267,000	Very Good

^{1/} Includes construction cost, contingency, engineering and administrative costs.

^{2/} Includes present worth of construction and replacement costs.

^{3/} Includes amortized construction and replacement costs and annual operation and maintenance costs.

^{4/} Assuming uniform implementation over a ten-year period.

Public Acceptance			
<u>Alternative</u>	<u>Community At- Large</u>	<u>Floodplain Residents</u>	<u>Overall Attractiveness</u>
1 - Flood proofing Structures	Unfavorable	Favorable	Fair
2 - Levees and Flood proofing 380 Structures	Favorable	Favorable	Very Good
3 - Levees, Evacuation of Floodway Adjacent Flood Fringe and Rational Use of Evacuated Land	Favorable	Unfavorable	Fair
4 - Dredging	Favorable	Favorable	Fair
5 - Renovation of Canal and New in Sears Dam	Favorable	Favorable	Poor

1/ Includes construction

2/ Includes reconstruction

3/ Reduces flood damage

Exhibit 9

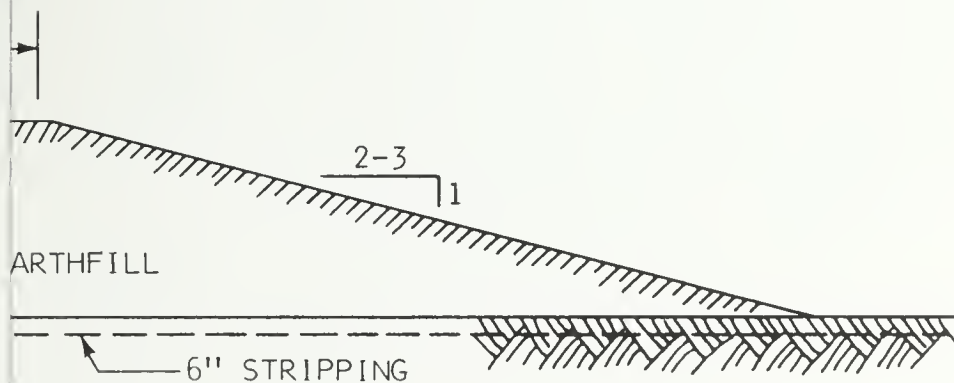
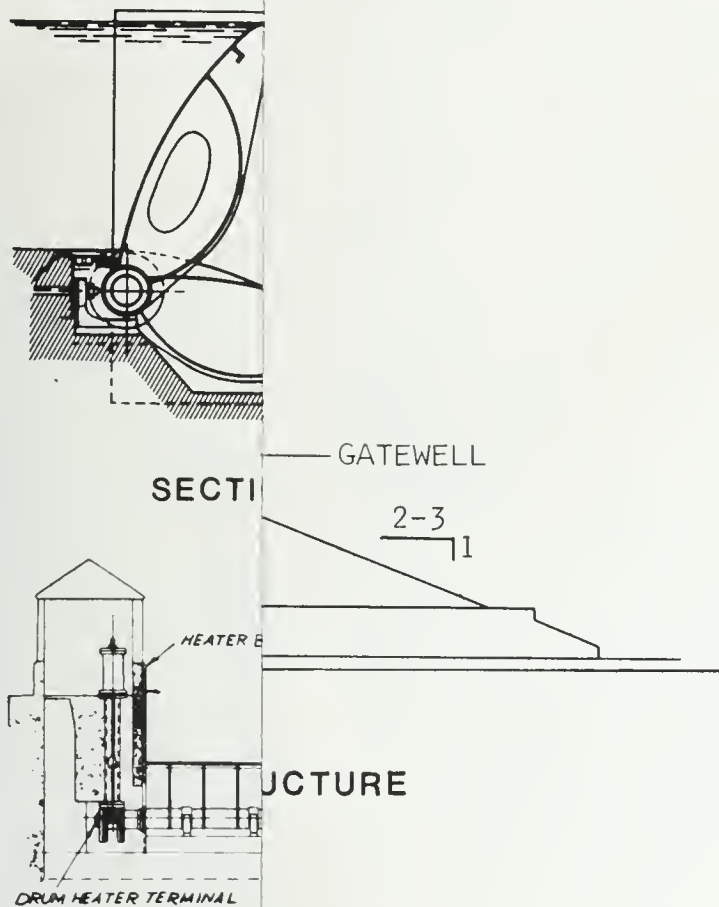
EVALUATION OF ALTERNATIVE PLANS
FOR ALLEVIATION OF FLOOD DAMAGE
LOWER ROCK RIVER NEAR MOLINE ILLINOIS

<u>Alternative Plans</u>	<u>Economic Evaluation</u>					<u>Number Structures Protected</u>	<u>Number Structures Unprotected</u>	<u>Reliability of Performance</u>	<u>Public Acceptance</u>		
	<u>Initial Cost^{1/}</u>	<u>Annual Cost^{2/}</u>	<u>Annual Benefit</u>	<u>Annual Residual Damages</u>	<u>Benefit- Cost Ratio</u>				<u>Community At- Large</u>	<u>Floodplain Residents</u>	<u>Overall Attractiveness</u>
1 - Flood proofing 1380 Structures	2,870,000	196,100	297,000	131,800	1.51	1,380	0	Good	Unfavorable	Favorable	Fair
2 - Levees and Flood proofing 380 Structures	2,550,000	178,300	282,400	146,400	1.58	1,380	0	Very Good	Favorable	Favorable	Very Good
3 - Levees, Evacuation of Floodway and Adjacent Floodway Fringe and Recreational Use of Evacuated Land	20,700,000	1,240,000	1,041,000	150,000	0.84	1,380	0	Excellent	Favorable	Unfavorable	Fair
4 - Dredging	2,610,000	259,000	155,200	273,600	0.60	1,380 ^{3/}	0	Fair	Favorable	Favorable	Fair
5 - Renovation of the I&M Canal and New Spillway in Sears Dam	1,340,000	152,800	58,800	370,000	0.38	1,380 ^{3/}	0	Good	Favorable	Favorable	Poor

^{1/} Includes construction cost, contingency, engineering and administrative costs.

^{2/} Includes replacement and operation and maintenance costs.

^{3/} Reduces flood damage to all structures, but only to small degree.

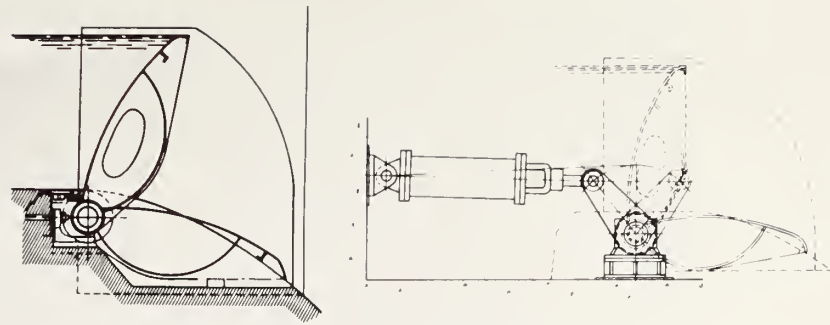


FLASHBOARD A

EXHIBIT 10

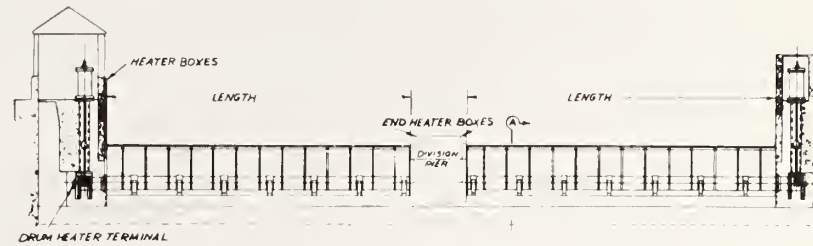
LAYOUT OF PLAN ELEMENTS

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY

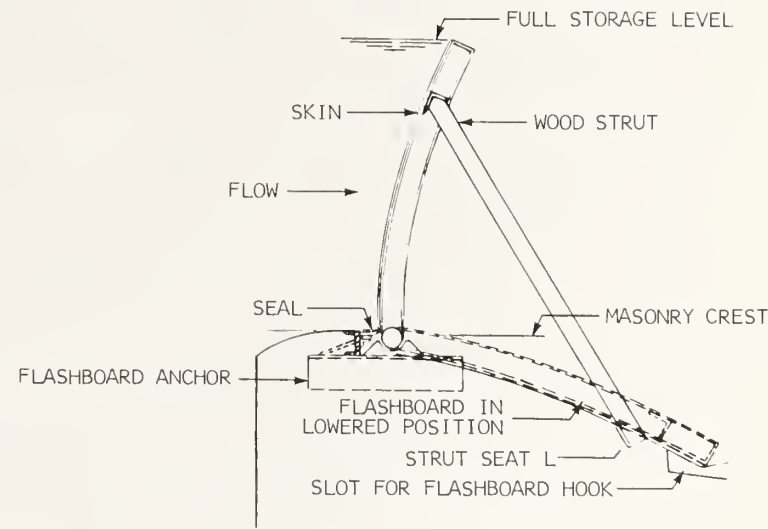


SECTION A

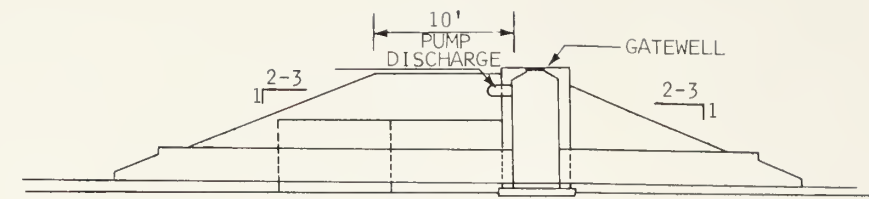
ALTERNATIVE PIER MOUNTING



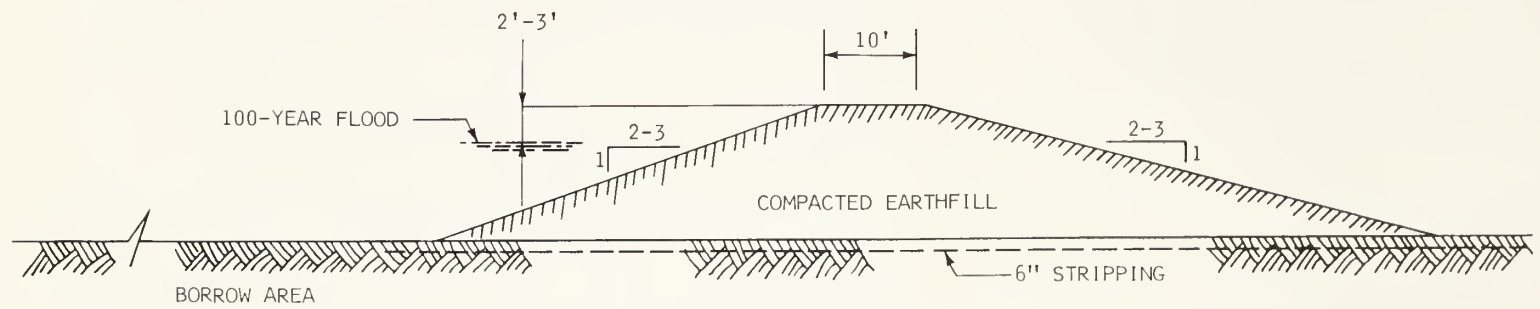
TYPICAL BASCULE GATE



TYPICAL HINGED FLASHBOARD

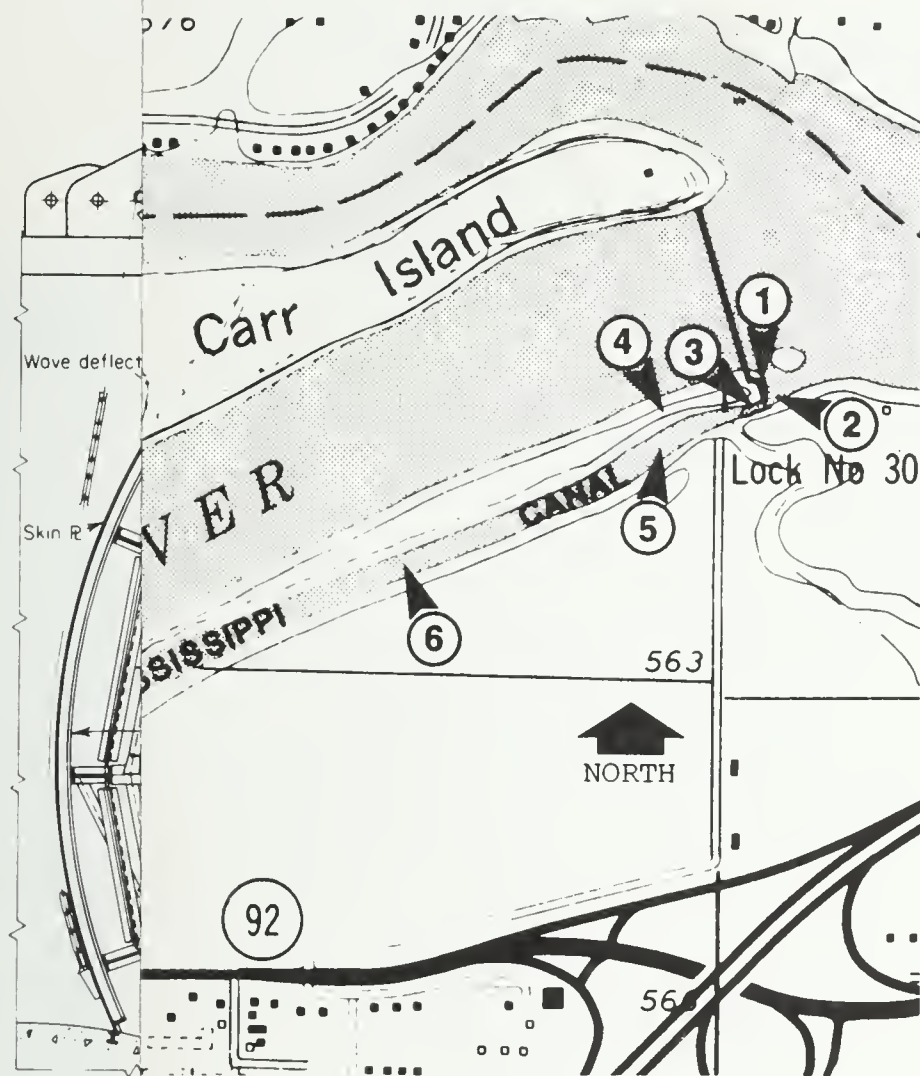


TYPICAL DRAINAGE STRUCTURE



TYPICAL LEVEE SECTION

EXHIBIT 10
**LAYOUT OF
 PLAN ELEMENTS**
 LOWER ROCK RIVER
 STRATEGIC PLANNING STUDY



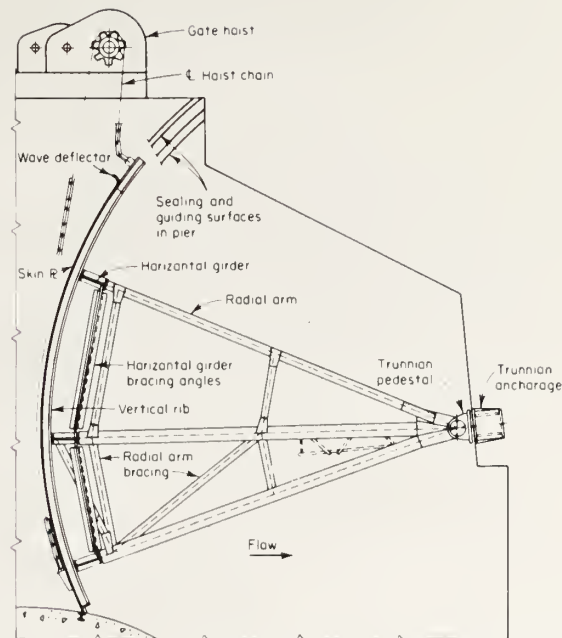
DETAILS

1 Tainter Gate)

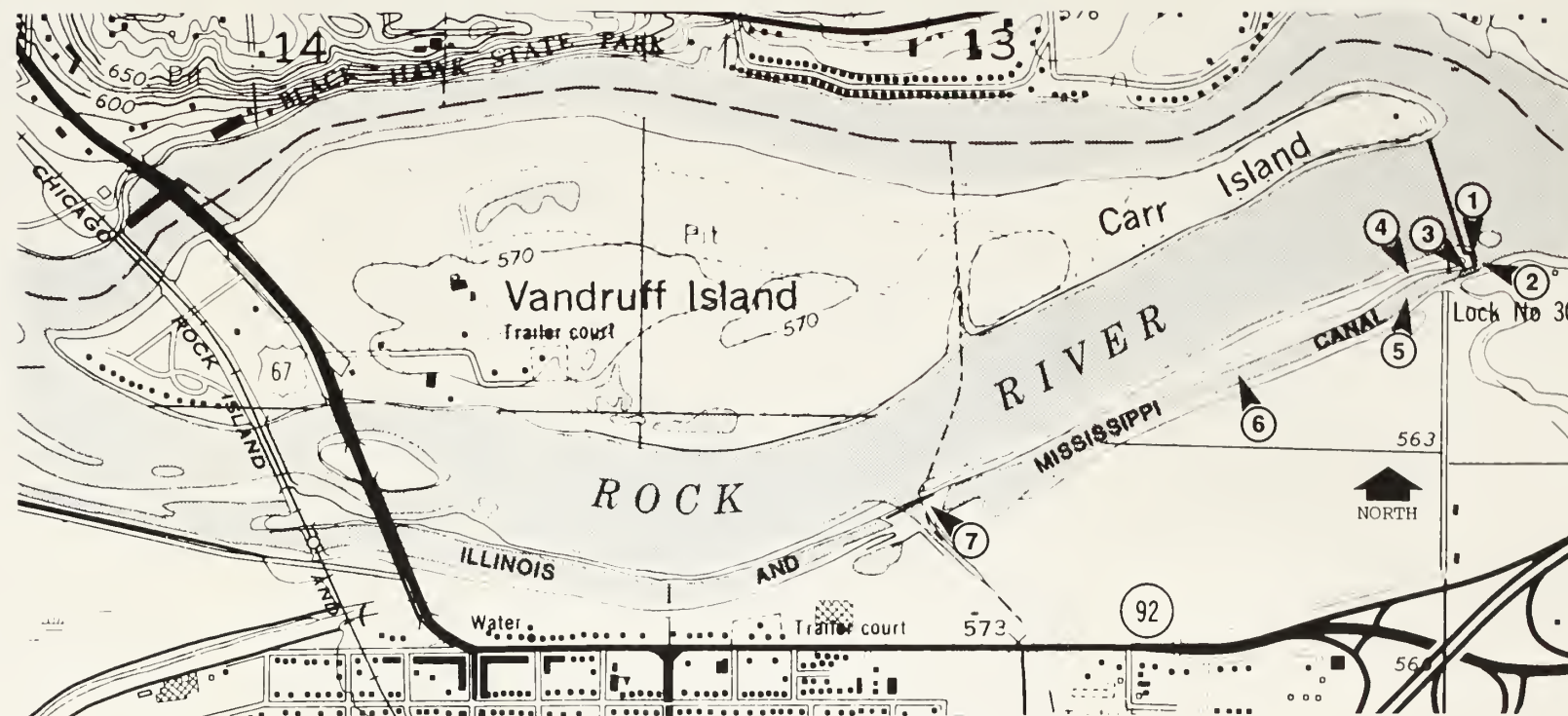
EXHIBIT 10

LAYOUT OF PLAN ELEMENTS

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



DETAILS OF A CONVENTIONAL TAINTER GATE
(SECTION THROUGH $\frac{1}{2}$ GATE)



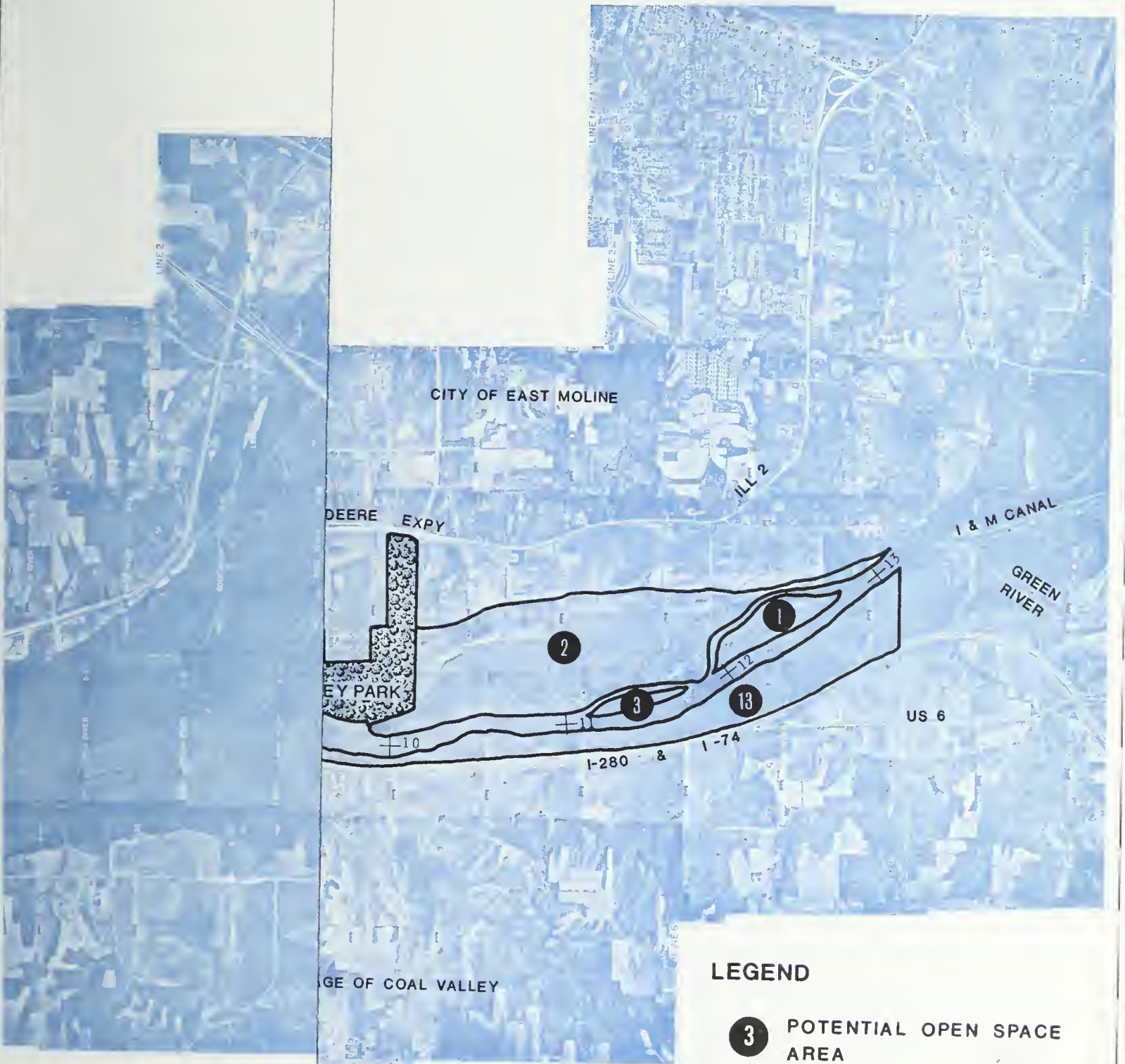
LOCATION OF IMPROVEMENTS

Scale 0 1/4 1/2 Mile

CONSIDERED IMPROVEMENTS TO I&M CANAL

PRIMARY

- ① INSTALL 3 NEW TAINTER GATES (See Detail of Conventional Tainter Gate)
- ② CLEARING OF EXISTING LOG JAM
- ③ CLEARING LOCK NO 30, GATE BAYS, AND CHANNEL
- ④ OPEN CHANNEL BETWEEN I&M CANAL AND ROCK RIVER
- ⑤ DIVERSION STRUCTURE
- ALTERNATIVE A (To ④ and ⑤ above)
- ⑥ DREDGING OF I&M CANAL FROM LOCK NO 30 TO MILL CREEK
- ⑦ REMOVAL OF UPSTREAM EARTH FILL AT MILL CREEK



LEGEND

- 3** POTENTIAL OPEN SPACE AREA
- + RIVER MILE

EXHIBIT 11

POTENTIAL OPEN SPACE LAND USE

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY

POTENTIAL OUTDOOR RECREATION AREAS

- 1 - NATURAL AREA; BOAT ACCESS
- 2 - NATURAL AREA; NATURE TRAIL, PICNIC AREA
- 3 - NATURAL AREA
- 4 - GREEN VALLEY PARK (EXISTING PARK)
- 5 - OPEN GREEN SPACE; BICYCLE, HIKING, OR EQUESTRIAN TRAIL
- 6 - PICNIC AREA, BOAT LAUNCH RAMP, PLAYING FIELD
- 7 - CAMPGROUND, BOAT LAUNCH RAMP
- 8 - BLACK HAWK STATE PARK (EXISTING PARK)
- 9 - OPEN GREEN SPACE
- 10 - OPEN GREEN SPACE
- 11 - NATURAL AREA; NATURE TRAIL, BOAT ACCESS
- 12 - SUNSET PARK (EXISTING PARK)
- 13 - GREENBELT; WILDLIFE SANCTUARY
- 14 - PICNIC AREA, BOAT LAUNCH RAMP, PLAYGROUND
- 15 - OPEN GREEN SPACE
- 16 - PICNIC AREA, BOAT LAUNCH RAMP, PLAYGROUND
- 17 - ILLINOIS-MISSISSIPPI CANAL; HENNEPIN PARK & SMITH ISLAND COMPLEX



LEGEND

- 3 POTENTIAL OPEN SPACE AREA
- + RIVER MILE

EXHIBIT 11
POTENTIAL
OPEN SPACE LAND USE
LOWER ROCK RIVER
STRATEGIC PLANNING STUDY



EXHIBIT 12

RECOMMENDED PLAN

LOWER ROCK RIVER
STRATEGIC PLANNING STUDY

UNIVERSITY OF ILLINOIS-URBA



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